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THE PENNSYLVANIA VEGETABLE FORCING INDUSTRY



Interior View of a Pennsylvania Greenhouse.

F. P. Willits, Secretary of Agriculture.

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PENNSYLVANIA DEPARTMENT OF AGRICULTURE

Organization and Services.

FRANK P. WILLITS, *Secretary*

JOHN M. McKEE, *Deputy Secretary*

This Department is essentially a service agency created by legislative enactment to deal with administrative, regulatory, investigational, and educational problems which can best be solved through public rather than individual action. The organization provides for coordination and cooperation with the Pennsylvania State College and the U. S. Department of Agriculture. The Department operates through the following bureaus:

ANIMAL INDUSTRY:

T. E. MUNCE, *Director and State Veterinarian.*

Prevents and eradicates transmissible diseases of animals and poultry, including tuberculosis of animals in cooperation with Federal Government.

Demonstrates to veterinarians control methods for transmissible animal diseases; Supervises vaccination for and the prevention of hog cholera, anthrax, black leg and hemorrhagic septicemia;

Protects public from unwholesome meats through ante and post mortem examinations of animals at slaughtering establishments;

Inspects, licenses and furnishes information as to breeding, soundness and conformation of stallions and jacks standing for public service;

Enforces law requiring licensing of dogs and providing for protection of livestock and people from attacks of uncontrolled dogs;

Maintains laboratory for diagnostic research and experimental projects.

PLANT INDUSTRY:

C. H. HADLEY, *Director.*

Tests agricultural seeds for purity and germination, and enforces State Seed Law;

Inspects orchards, parks, farms, and plant imports for injurious insects and plant diseases;

Inspects and licenses Pennsylvania nurseries, and licenses all dealers in nursery stock;

Enforces laws governing apicultural practices, disease control and housing;

Places and enforces quarantines and carries on eradication campaigns against insect pests and plant diseases;

Inspects and certifies potatoes for seed purposes;

Makes investigations for the control of injurious insects and plant diseases including field tests of insecticides, fungicides and weed killers;

Maintains collections of insects, plant diseases, plants, and seeds, and identifies specimens.

FOODS AND CHEMISTRY:

JAMES FOUST, *Director.*

Accomplishes its purpose of protecting Pennsylvania homes against harmful foodstuffs by sampling, analyzing, and bringing prosecution under the laws relating to foods and non-alcoholic drinks, including milk, cream, butter, ice-cream, eggs, sausage, fresh meats, soft drinks, fruit syrups, vinegar and kindred food products;

Regulates and issues licenses for the manufacture and sale of oleomargarine;

Licenses and regulates egg-opening plants and cold storage warehouses, maintaining regular inspection and enforcing twelve-month storage limit;

Inspects milk plants and creameries and regulates weighing, testing, buying and selling of milk and cream on a butterfat basis;

Protects honest manufacturers, importers, selling agents and ultimate users of feeding stuffs, fertilizers, lime products, linseed oil, paint, putty, turpentine, insecticides and fungicides, by means of annual registrations followed by inspections, analyses, prosecutions and the publication of the analyses of these products;

Analyses special samples for residents of the State at the rate of \$1.00 a sample for feeding stuffs, lime products and linseed oils.

MARKETS:

P. R. TAYLOR, *Director.*

Investigates and assists in the marketing of farm products; at present chiefly grain and hay, fruits and vegetables, poultry and eggs, and tobacco;

Compiles and distributes daily market information as to supplies, shipments and prices;

Advises growers on transportation of agricultural products;

Assists cooperative associations and public markets;

Establishes standard grades of farm products and maintains inspection;

STATISTICS:

L. H. WIBLE, *Director.*

Assembles and disseminates essential statistics and facts pertaining to the agriculture of the State, from monthly reports rendered by hundreds of volunteer crop correspondents, information which assists the producer in his sales and interests all industries which deal with agricultural products;

Cooperates with U. S. Bureau of Agricultural Economics in joint crop and livestock reporting and publishes annual and monthly summaries of the data;

Compiles dates of county and local fairs and assembles data pertaining to their success and results during each year.

SUMMARY

Vegetable forcing is practiced in more than 30 counties of Pennsylvania. The greatest development in the greenhouse industry is found near Erie, New Castle and Kennett Square with an important frame forcing business near Philadelphia.

Pennsylvania was credited by the 1920 census with receipts of nearly one and three quarter million dollars in 1919 from the sale of greenhouse vegetables and vegetable plants.

Lettuce, tomatoes, cucumbers and mushrooms are the principal vegetable crops forced. Leaf lettuce is the most popular vegetable forcing crop but the competition from California head lettuce may eventually force the substitution of other crops.

Heating by steam is the most popular method in greenhouses covering over 10,000 square feet of ground.

Greenhouse soils are usually heavily fertilized with both animal manures and commercial fertilizer, and regularly treated with lime.

Fifty per cent of the growers who do not use benches and hence do not change their soil each year or two, sterilize their soil with either steam or formalin.

Preventive measures and fumigation are largely depended upon for the control of insects and diseases.

The use of labor saving devices is an important factor in cutting down the cost of growing vegetables under glass.

While the principal forcing districts do some shipping, a large proportion of the Pennsylvania forced vegetables is marketed locally. As a whole the direct-to-retailer method of sale is most popular.

While there is no standard package used in the marketing of forced vegetables, the splint market and climax baskets are quite generally used.

Competition in the vegetable forcing industry comes mainly from California, Ohio and the Southern states.

Opportunity for expanding the vegetable forcing industry is afforded in many sections of Pennsylvania.



THE PENNSYLVANIA VEGETABLE FORCING INDUSTRY¹

By C. R. Mason

Vegetable forcing in Pennsylvania increases in size and importance each year. Until recently no accurate detailed survey of this industry had ever been made. Since the greenhouse ranges are more or less scattered through at least 34 counties of the state the extent of the business has never before been fully realized.

Pennsylvania vegetable forcing may be divided into the following groups:

1. The use of frames for the growing of vegetables for market.
2. The growing of vegetable plants for spring sales or field setting.
3. Growing vegetables for market in greenhouses.
4. Use of greenhouses for the production of vegetables for home use only.
5. Growing of French endive and rhubarb.
6. Mushroom production.

A survey has been completed which shows that over 40 acres of ground are covered by commercial vegetable greenhouses in Pennsylvania. In addition, nearly all market gardeners have sash for plant growing or the forcing of vegetable crops to maturity, the number varying from a half dozen sash to frame yards of 2,000 to 3,000 sash in Philadelphia County. The total for the state of 100,000 sash covers over a million and three quarter square feet of soil. There are many florists' establishments that make a practice of growing vegetable plants for sale to commercial and home gardeners. A few large estates boast private greenhouses in which vegetables are grown for home use, and considerable space is given to the forcing of rhubarb and chicory either in greenhouses or in special houses or cellars adapted for these crops. The mushroom industry includes four million square feet of actual bed space with an output running into millions of pounds of mushrooms annually. This industry is discussed in Bulletin 392, recently issued by the Pennsylvania Department of Agriculture.

¹This bulletin is a second of a series of three on the vegetable industry of Pennsylvania. The series is made possible through the cooperation of vegetable growers and members of the staffs of the Pennsylvania State College and the Pennsylvania Department of Agriculture. Special mention is due Professor W. C. Felton and W. B. Nisley of Pennsylvania State College.

PENNSYLVANIA RANKS HIGH IN VEGETABLE FORCING

The 1920 census figures show that Pennsylvania ranked third in receipts from the sale of greenhouse vegetables and vegetable plants during 1919, with total returns of \$1,720,631. For the whole United States the receipts were \$15,487,878. The four other leading states were Ohio \$2,740,686, Massachusetts \$1,930,934, Illinois \$1,547,906 and New York \$1,450,604.

More than one-half (53.7 per cent) of the total area under glass in greenhouses (both flowers and vegetables) on January 1, 1920, was reported as follows: Illinois 19,626,091 square feet, Ohio 19,397,183 square feet, New York 18,289,628 square feet, Pennsylvania 16,923,355 square feet, and Massachusetts 12,953,023 square feet. No other States reported as much as 10,000,000 square feet under glass in 1920. The number of establishments reporting receipts from the sale of greenhouse products in the four states leading in this respect were as follows: New York 2,508, Pennsylvania 2,228, Ohio 1,667 and Illinois 1,104.

A few years ago out-of-season vegetables raised in greenhouses were considered luxuries to be purchased only by the wealthy. But in recent years, as the value of fresh vegetables in the diet has become more generally known, and efficient methods of production have lowered the comparative cost to the consumer of greenhouse products, **the use of lettuce, tomatoes, and other such fresh vegetables in winter has come to be looked upon as a necessity.** With the consequent increased demand for forced vegetables, there have been a number of greenhouses built in many parts of the United States, and there is bound to be a still greater increase in the future to keep step with larger demand.

In California, Florida, and other states with mild winter climate the acreage of vegetables grown to supply Northern and Eastern markets during the winter months is steadily increasing; yet due to the higher quality of most of the vegetables produced in the greenhouse these can still compete favorably with the shipped-in-products grown outdoors.

Opportunities for vegetable forcing in Pennsylvania were never better than at present. The prices on greenhouse construction materials have dropped somewhat within reason, and as a consequence, **in 1923 and 1924 there were a number of small new ranges built and an expansion of established greenhouses.** There is plenty of room for greater expansion in many districts of the state.

STATE HAS MANY ADVANTAGES

Pennsylvania offers the following advantages to those who wish to find a location favorable to vegetable forcing:—

1. There are many manufacturing and mining towns and cities in the state which are under-supplied during the winter with lettuce, tomatoes, spinach, and other vegetables, that may be produced profitably under glass.

2. Pennsylvania as a great coal producing state, offers an opportunity to greenhouse men to secure fuel at a cost much lower than many other states.

3. Soils in many sections are most favorable to the production of vegetables, the supply of water is generally abundant, and manure may often be secured locally at a fair cost, shipped from the larger cities as New York, Philadelphia, and Pittsburgh, or obtained from other convenient sources as the stock-car cleaning stations in North-eastern Ohio.

4. Transportation facilities are being greatly improved with the building of many miles of state highways and good county roads. Both steam and electric lines are available in some sections, and near the larger markets these facilities are excellent.

5. The climate of Pennsylvania is not severe enough to make the cost of greenhouse heating unreasonably high, and the amount of sunshine during the dull, winter days, is sufficient to grow greenhouse crops at a profit.

That there is profitable return to be made in vegetable forcing in Pennsylvania by the right methods is undeniable. Conditions favoring the industry are present in the state, though the likelihood of failure is at least as great as in other branches of intensive agriculture. Good construction, careful management, rigid grading of products, honest and attractive packing, and wise marketing of the crops—all have proved essential to success in the growing of vegetables under glass.

IMPORTANT FORCING SECTIONS

There are three main vegetable forcing centers in Pennsylvania—Erie, New Castle, and Kennett Square, though vegetable greenhouses are scattered throughout the state, mainly near the larger cities as Altoona, Johnstown, and Wilkes-Barre. The largest chicory-forcing establishments in the East are located in Bradford County, while the only commercial melon range of importance in the United States is operated near North Wales, Montgomery County. The chief frame forcing section is in Philadelphia County. The business of raising vegetable plants in the spring in frames and greenhouses is scattered throughout the state.

ERIE

The industry in the Erie Section was inaugurated over 20 years ago by C. W. Zuck, of the present firm of C. W. Zuck and Sons. From

a small beginning this firm has gradually increased its range until it now covers 6 acres of ground, F. M. Feasler was the second grower in the Erie section to build greenhouses and he has been followed by others until now there is a total of over 10 acres devoted to vegetable forcing in this section. All of the growers started in a small way and gradually increased the extent of their ranges, so that the growth of the industry in Erie has been healthy, just keeping a pace or so in back of the demand for greenhouse products.

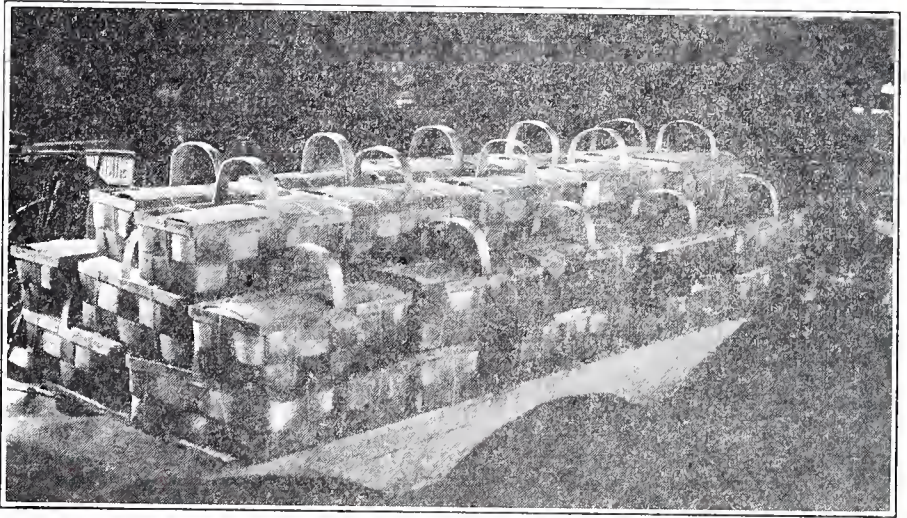


Fig. 1. Single baskets of lettuce ready for shipment by Parcel Post from the Erie Section to many cities in western Pennsylvania.

The vegetables raised here include only lettuce, tomatoes, cucumbers and a little parsley, all but cucumbers grown throughout the season and cucumbers, interplanted with lettuce, grown as spring crops.

NEW CASTLE

There are 10 vegetable forcing establishments in the New Castle section, ranging from small flue heated houses to W. H. Weinschenk's large range covering over two acres. The total area of ground covered by glass in this section is nearly 6 acres. W. H. Weinschenk is the pioneer grower of the neighborhood and his practices largely set the standard for the section. The main greenhouse crops grown are lettuce, through the fall and winter, with occasionally a fall crop of tomatoes; cucumbers and tomatoes in the spring, with New Zealand spinach now occupying a prominent place as a fall, winter, and early spring crop, and parsley, rhubarb, radishes, green onions, mushrooms, and vegetable and flower plants as minor crops.

KENNETT SQUARE

As a rule in the Kennett Square district, the vegetable forcing industry is combined or closely associated with mushroom growing or floriculture or both. The growers are few in number and the ranges are comparatively small. Several firms formerly engaged in vegetable forcing have recently switched to the production of flowers. The greenhouses are scattered chiefly along the Pennsylvania railroad, and none are separated more than 4 or 5 miles.

Tomatoes and mushrooms are the only two vegetable crops grown. Tomatoes are grown either throughout the year, as a spring crop following tomato plants that have been producing through the fall and winter, or in a rotation with flowers such as sweet peas, chrysanthemums, or mignonette. Mushrooms are frequently produced under the benches on which tomatoes or flowers are grown.

LOCATING THE VEGETABLE FORCING RANGE

Many of the growers now engaged in vegetable forcing in Pennsylvania did not choose their locations primarily for this business. In most cases men simply picked out a desirable site in their home community, or built a greenhouse range in connection with a well established market garden. In some cases, they were attracted to a locality because of other successful vegetable forciers already in business there. When locating a vegetable forcing range in this state, the following factors should be considered.

MARKETS

1. The ability to place forced products on good local markets has many advantages over shipping. If there are no desirable nearby markets, then transportation facilities should receive much consideration.

TRANSPORTATION FACILITIES

2. Good roads are essential for marketing locally, if a haul is necessary to reach shipping point, or if marketing in other towns within trucking distance. Location on a railroad or electric line where a siding may be secured is desirable for shipping the products or for receiving coal, packages, and other supplies.

SOILS

3. Heavy types of soil may be changed greatly over a period of years, but sandy types are much preferred as a foundation.

WATER SUPPLY

4. A sufficient supply of water is an absolute necessity. It has been estimated that an average of nearly 250 gallons of water is re-

quired daily per acre during the months of May and June to satisfy the needs of vegetables grown in greenhouses during that period of the year.

COAL COST

5. The advantage of location near a mining section lies in the fact that coal may often be obtained at a low rate. Since fuel is one of the largest items of expense, this should be considered. However it may be profitable to pay a higher rate for coal for the privilege of locating near good markets, and with other advantages such as desirable soil, or ample water supply.

LABOR SUPPLY

6. In many of the larger ranges, transient labor is used in rush seasons for such work as transplanting plants. Steady labor, is of course, more desirable. Labor should be obtainable at a reasonable rate.

MANURE SUPPLY

7. Since vegetable forcers use large amounts of animal manures annually, the cost of securing manure should be investigated.

THE ATMOSPHERE

8. Should be free from smoke and gases poisonous to plants. A location with a maximum of winter sunshine is greatly to be desired. The amount of sunshine varies in different sections of the state and local weather bureau reports should be consulted in this regard. The Erie section is lacking in winter sunshine, yet other conditions such as soil and transportation are favorable. The lack of sunshine in the Erie district has furthered the growing there of crops in the fall and winter that do not require a high degree of light, such as lettuce and parsley. The growing of tomatoes in the dull weather season in this section is just being attempted while near West Chester (Kennett Square) with a greater number of clear winter days winter tomatoes have long been successfully grown.

FRAME FORCING IS EXTENSIVE BUSINESS

The principal frame forcing section of Pennsylvania is located in Philadelphia and Delaware counties where a total of 40,000 sash are in use. Throughout the state hotbeds, coldframes, and small sash greenhouses are used for the production of vegetable plants, but only in the section above mentioned is followed to any extent the practice of growing crops to maturity in coldframes.

Manure, hot water, and steam heated frames or hotbeds, constructed of wood, brick, and concrete, are operated with success in Pennsylvania for plant growing. The typical frame used in southern Pennsylvania, however, is a portable, roughly built sort.

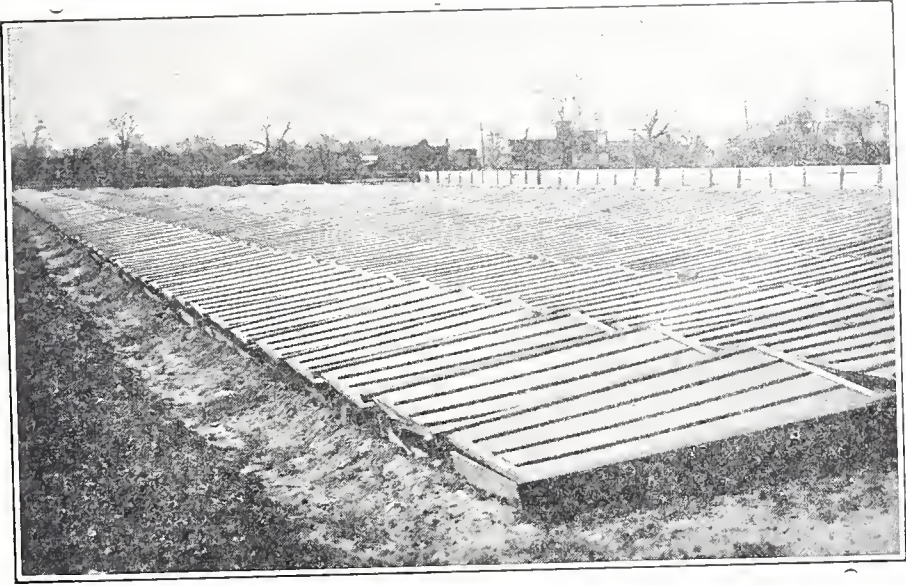


Fig. 2. Frame yard in South Philadelphia Section. Note board fence used as windbreak.

These cold frames are usually made of cheap, undressed boards, $1\frac{1}{4}$ inches thick, 6 to 10 inches wide, and 12 to 16 feet long. The rear wall will be made 10 to 16 inches in height, with the front wall 4 to 6 inches lower, except for Rhubarb forcing in which case deep frames are used. The slope thus made faces toward the south or southeast in order to get most benefit from the sunlight. The frames are made six feet wide and any length desired, to accomodate standard 3' x 6' sash. Frame yards are often protected from prevailing cold winds by tree windbreaks or by board fences, as shown in Figure No. 2. The wall and end boards of the frames are held in place by 2" x 3" stakes driven two or three feet into the ground along the outside edge of the frames.

Narrow paths about two feet wide are provided between the frames. In a few cases frame crops are watered by the overhead irrigation system but the hose is commonly used. Such temporary frames as just described are usually shifted to new locations each season, thus providing for the use of new soil and consequent rotation of crops. During the summer the frames are dismantled and the boards and sash stacked until needed again toward autumn. Cloth covered frames, are used infrequently for vegetables in Pennsylvania, because of insufficient protection afforded the crops. Standard sash 3' x 6' with three runs of 10" x 12" glass are commonly employed in this state.

Soil for frame forcing is manured heavily, plowed, commercial fertilizers often used, and a very smooth seed bed prepared. This preparation is often accomplished before the frames are set up.

Special attention is given to ventilation and watering. Fresh air is essential to healthy plants, though comparatively little is admitted during the coldest weather to wintered-over vegetables. As a rule no watering is done in winter, unless the season is exceptionally dry, but after March the usual amount of watering is needed for frame crops.

The market gardeners in the Philadelphia section use their frames for the following purposes: The growing of vegetable plants to be used in the field, as cabbage, cauliflower, celery, eggplant, kohlrabi, leek, lettuce, pepper, tomato, etc.; the production of crops to maturity, as head lettuce, early cauliflower, early carrots, early beets, kohlrabi, radishes, spinach, parsley, and dandelion; the forcing of rhubarb; the growing of fall crops, as escarol and endive; and the storage of vegetables, as celery.

The frames are usually erected in the late summer, used for the production of fall crops and the holding of plants over winter, then the growing of plants and mature crops in the spring. The frames are taken up and stored in the summer, and the land they occupied is used for late season crops. A common practice for men who do not have hotbeds or greenhouses, is to use frames to carry certain vegetable plants over winter for transplanting to the field in early spring, or to mature in the frames at that season. These include: cabbage, cauliflower, and lettuce for field setting, and cauliflower, carrots, head lettuce, dandelion, parsley and spinach for maturity in frames. Jersey Wakefield Cabbage, Snowball Cauliflower, Dutch Butter, Big Boston, and Paris Cos (Romaine) Lettuce are the chief varieties of the commoner vegetables used in growing "wintered" plants.

Companion cropping is extensively practiced in the Philadelphia forcing frames. The combinations used include:—

Head lettuce and carrots in alternate rows, lettuce usually fall sown, and transplanted in the spring 8 to 12 inches apart, between rows of carrots sown either in the fall or the spring.

Beets and radishes in alternate rows about 4 inches apart, both spring sown.

Early cauliflower, winter held plants, set 16" x 16" in the spring interplanted with "wintered" head lettuce; with radishes, two rows sown in the spring in each interspace between the cauliflower; or with double rows of carrots, also spring sown.

Spinach and beets in alternate rows, spinach fall sown, beets seeded in the spring.

Head lettuce or cauliflower interplanted with leeks.

One of the main difficulties in the growing of frame lettuce is furnished by the disease known as Drop. Experiments in the Philadelphia Section have shown a great reduction in this disease through the sterilization of frame soils with a formalin drench.

MARKETING. The principal package used for all frame grown vegetables in the Philadelphia districts is the market box. The production of frame head lettuce in the Philadelphia section has been curtailed in recent years due to the strong competition of head lettuce shipped from the trucking districts of the Southern Atlantic Coast States. The following table showing the shipping seasons for important states sending lettuce into Philadelphia in 1923 indicates the periods at which head lettuce competition may be expected by the Philadelphia producers of frame head lettuce and the leaf lettuce growers who might ship their product to Philadelphia:

<i>State</i>	<i>Opening Month</i>	<i>Closing Month</i>
California	November	October
Florida	November	May
Arizona	Dec.	May
South Carolina	Feb.	May
North Carolina	Mar.	May

SELECT GREENHOUSE SITE CAREFULLY

The site selected for the location of a greenhouse as exemplified by Pennsylvania conditions should be fully exposed to the sunlight but protected from the prevailing cold winds and from storms by the natural lay of the land, by woodland, or by artificial windbreaks. Such protection not only saves great damage from breakage of glass and twisting of framework, but cuts down the coal bill as well. Level ground or a slight slope have advantages over steep slopes though the latter have been used for greenhouse situations in this state. On the level ground water may be more evenly applied, it is more convenient to work, and the house is kept with less trouble at a uniform temperature.

The question of the position of a greenhouse with reference to the points of the compass, has never been definitely settled. Some growers prefer to run their houses from East to West, others from North to South. The former direction provides for the admission of more sunlight during the short days of winter, while greenhouses running from North to South provide a more uniform distribution of light and are more comfortable to work in during the hot days of early summer. The above comments apply particularly to the even span house. The uneven span house should run either East and

West, or Northeast and Southwest with long span facing South or Southeast, in order that the proper amount of sunlight may be secured.

CONSTRUCTION AND ARRANGEMENT IMPORTANT

The construction of vegetable forcing houses varies considerably, both in type of houses built and the materials used in their construction. Since all types have certain advantages, the form and size are largely matters of personal preference of the builder, or may depend on the capital available and on the site selected. The tendency of those building at present in this state seems to be toward the even-span, separate house 30 to 80 feet in width and 150 or more feet in length.

Vegetable greenhouses now built in this state are from 10 to 120 feet in width. This smallest width is well represented by 10 x 200 feet houses in Montgomery County, used for the growing of melons. The largest vegetable house in the state is located at New Castle. This is a hillside uneven span house 120 feet wide and 600 feet long. At North Wales there is an even span greenhouse 172 feet wide, at present used for the production of flowers. This extreme width, however, has not proved satisfactory due to breakage in storms. Eighty feet seems to be considered the greatest practical width for the even span house.

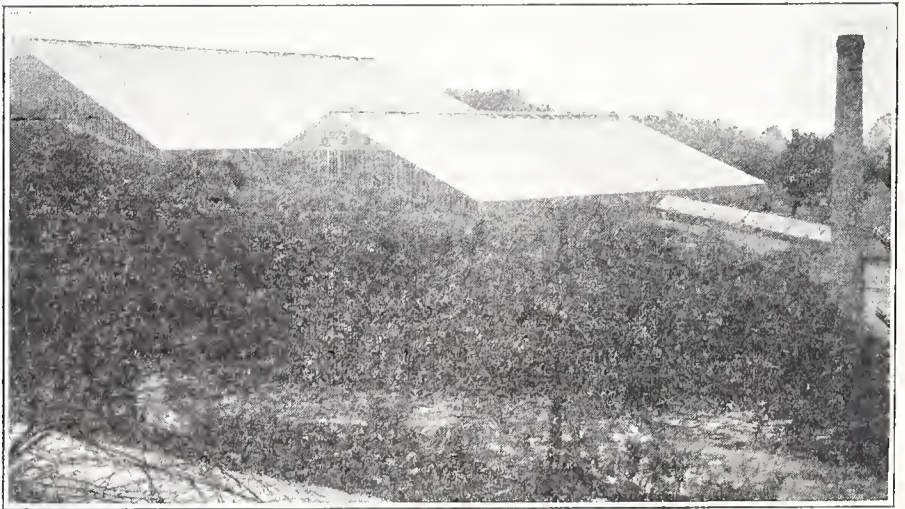


Fig. 3. Uneven span houses on side of hill, New Castle, Pa.

Any convenient length is used, 150 to 200 feet being most common. Two hundred feet is the maximum length that is satisfactorily heated by the gravity hot water system. A single large house has certain advantages over several smaller units with total areas equal

to the large house, such as economy of heating and more uniform temperature due to greater volume of air. However, the cost of construction and difficulty of repair work and cleaning glass (where this is necessary), are greater with the larger houses. As a rule, the eaves of greenhouses are now made from 6 to 7 feet high, for convenience in working along one edge of the house. The walls are commonly concrete, a foot wide at the base and 8 to 10 inches at the top, with this section of the wall extending one foot or more above ground. The remainder of the wall to the eaves consists of sash bars and glass similar to the roof.

Separate houses are preferred somewhat to connected houses, in some sections of the state, while many growers favor the latter, known as the ridge and furrow type. The connected houses save expense in wall construction, and are cheaper to heat, but in the separate houses a greater amount of light is admitted. The gutters in the connected type cast a great deal of shade, extra heat may at times be necessary in the ridge and furrow houses to melt off the snow that collects in the gutters, or with a heavy snowfall the snow may have to be shoveled out of the gutter.

There are two main types of houses, classified according to the length of the roof bars on either side of the ridge—the even span and the uneven span. On level ground the even span house seems to be preferred, though a few growers favor the $3/4$ span, with the long span facing the South or Southeast. The advantage for the uneven span thus placed is the greater intensity of sunlight admitted during the morning. The even span house on the other hand has more uniform light conditions through the house during the entire day.

The greatest use of the uneven span house is found in the New Castle district where several large houses are built on rather steep South or Southeast hillsides, the ground sloping in parts of the houses as much as 3 inches to the foot. The long spans of these houses follow somewhat the contour of the land (See Figure 3). Such construction covers a maximum area of ground for the amount of glass involved, but has certain disadvantages. These include inconvenience of working crops on the slope, difficulty of giving uniform watering, and some trouble in heating the houses uniformly due to the fact that the warm air tends to rise to the upper part of the house and make the temperature at the lower end at the base of the hill too low. This latter trouble is overcome by the New Castle growers by placing the greater amount of radiation at the lower sides of the houses.

The older type houses are generally of semi-iron construction, with wooden framework, and posts, purlins, and braces of iron. A few houses are of all wood construction but the only advantage of this type is the low initial cost of building material. The popularity

of the above two types is on the wane in some sections with the all iron house to the fore. In the latter, all parts save the sash bars are of iron. The best of the iron houses have a limited number of purlin posts or none at all, the roof being suspended by trusses. The elimination of these posts makes much easier all cultural practices in the houses, and in the larger establishments teams and horse implements are used for spreading manure, plowing, and harrowing.

Provision is made in all houses for thoro ventilation in order that the plants in such an enclosed space may not suffer from lack of fresh air. For houses 20 feet or more in width, it is customary to provide two lines of ventilators, one on either side of the ridge. These may be continuous clear along the ridge or there may be a run or two of glass between every two ventilating sash. In some cases the sash are hinged at the ridge, in others at the header, the former having the advantage of preventing snow and rain from coming in the openings, but a disadvantage over the type hinged at the header, in that ice forming from the condensed water running off the ventilating sash will prevent their closing; but if the sash are hinged at the header, this water will run off the sash before freezing. Side and gable end ventilating sash are provided in many of the larger houses so that temperature and humidity may be more quickly changed if necessary.

The unit of a greenhouse range as a whole should be so grouped that the boiler, packing room, coal room, and office are centrally located so that from any of these places the crop houses may be reached conveniently. Such arrangement is found in many of the larger ranges of the State.

Hauling of coal and manure are costly items in production, and plans made to simplify the handling of such material are desirable. Large end doors in the crop houses for the admission of teams and centrally-located, wide concrete walks for handling the crops as harvested, are among the factors which cut down costs of production in some of the larger Pennsylvania forcing houses. Greenhouse materials may be shipped from the factory ready to put together so that many firms assemble and erect their greenhouses with only local help.

Double strength "A" glass is commonly used for glazing greenhouses. In the older wooden and semi-iron houses, small sizes of glass were in vogue. With improved methods of construction larger size glass, as 20" x 24" is now most popular. The glass is lapped in the roof since although the laps collect dirt, the rain is shed better than with butted glass, and glass is easier to replace in case of breakage. Butted glass is sometimes used for the walls and gables, but when glass is broken, it is necessary to cut the new pane

very accurately in order to make it fit, even then a tight joint is almost impossible.

The use of paint both outside and inside the greenhouse has not been emphasized in this state. We find many ranges that are neglected in this respect—on the other hand we have progressive greenhouse owners who paint their entire ranges every year or two. Such practice has the effect not only of preserving the wood and metal parts, but also of lightening the interior and giving the whole establishment a better appearance. "Good appearance is a fine advertisement" is the belief of one grower who paints at least every two years.

In smoky sections it is often necessary to clean the glass every season in order to admit the maximum amount of light for healthy plant growth. For this purpose a dilute solution of oxalic acid is commonly used, applied with a large brush or mop, and followed by clear water.

SHALL BEDS OR BENCHES BE USED?

In Pennsylvania greenhouses, we find three types of bed construction for the growing of vegetables: (1) flat or ground bed; (2) raised bed; (3) benches.

In the first type, the flat bed, the cropping area is on a level with the walks. This type permits ease of management in that on first construction, little soil need be hauled in if the ground over which the houses are built is already in good condition; manure, sand and fertilizers are applied to make the soil as nearly ideal as possible, and the soil spaded or plowed. The flat bed, especially where center posts are lacking, permits the use of labor-saving field implements, such as plow, harrow, and manure spreader. The soil must be well drained where the flat bed is used.

The raised bed is built up 8 to 12 inches above the general ground level, and is usually not over six feet wide, so as to permit ease of working from either side. The raised bed provides better drainage in case the greenhouse is built over a poorly drained situation but is un-economical of space since walks must be provided between the beds. The soil must also be entirely prepared with hand tools.

Benches are used extensively in the Kennett Square district. A few growers in other parts of the state, who have small ranges use benches for lettuce, radishes, and parsley. Benches are of value in growing the fall and winter tomato crops in that good drainage and bottom heat are secured. They are naturally of some advantage in that double cropping is possible, as with tomatoes or lettuce on the benches, mushrooms or rhubarb underneath.

However, benches are costly to construct and keep in repair, they necessitate the changing of soil every year since sterilization has

not proved entirely practical on wooden benches, they dry out more quickly than beds, and like raised beds, they are uneconomical of space.

LABOR SAVING DEVICES

Since labor is the largest single item of cost in growing any greenhouse crop, it is essential that work be done as efficiently as possible. No better ways of cutting down the labor cost of growing vegetables in the greenhouse can be conceived than the use of tools and devices such as are here briefly mentioned.



Fig. 4. Along a railroad spur is located this manure pit into which manure is unloaded by automatic carrier directly from car, Erie, Pennsylvania.

The building of large houses on level ground and with truss roof construction has permitted one Erie firm to use horse implements for the preparation of the soil and the spreading of manure. In Ohio ranges tractors are often called upon for the plowing but these have not come into use in Pennsylvania. The Erie firm also uses the following equipment: Low four wheel metal trucks on which fit wooden platforms or trays. On these are hauled crops from the houses to packing shed and from packing shed to loading station; A slowly revolving wheel that passes through a water tank and on which packed baskets of lettuce are placed for dipping; Bundle tier for tying baskets.

A New Castle grower dips his lettuce before packing it. For this purpose wire trays holding 100 pounds of lettuce are lowered into water tanks by block and tackle.

Where benches are used a great deal of time is needed for the annual filling of these benches. A Kennett Square firm economizes time and labor by taking in both soil and manure on a small car run on a 15 inch portable track, similar to the type used for hauling compost into mushroom houses.

Tile sterilization has been used in only one Pennsylvania vegetable house. After the tile are once laid, this system takes much less attention and labor than other devices for steam sterilization.

The use of overhead irrigation is commonly practiced throughout the state as a labor saving expedient.

HOT WATER AND STEAM HEAT EQUALLY POPULAR

There are 3 types of heating used in Pennsylvania vegetable greenhouses; hot air, hot water, and steam. Of these the hot air flue is reported as used in only three ranges, two small units in the New Castle district and one in Cumberland County. The system is said by the users to be entirely satisfactory and since only cool crops are grown, no high temperatures are required. In the first two ranges mentioned, the brick flue is run from the furnace in the head house midway between two narrow, connected houses to the chimney at the opposite end. This flue is built on the ground under a cropping bench.

The hot water system is used in many of the smaller greenhouses but steam has proved most popular in the larger houses. This is due

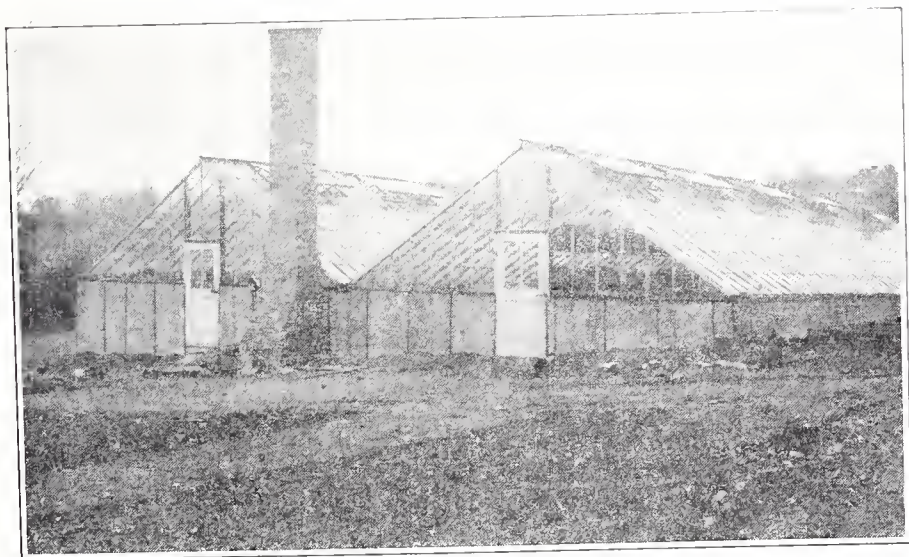


Fig. 5. Flue heated greenhouses in western Pennsylvania.

in part to the fact that forced circulation is necessary with hot water if the houses are over 200 feet long. For the smaller greenhouse the hot water system requires less attention during a greater

part of the season than does steam, since the fire may often be banked in the evening and temperature in houses will decrease little until attention is again given the furnace in the morning. Hot water heat is also claimed by some growers to provide a better plant growing heat than steam. Steam on the other hand gives quick changes of temperature when such are needed and provides a means of steam sterilization of the soil.

The cost of hot water and steam heating is probably very nearly equal, the steam system requiring less capital to install but a greater amount of labor for operation than hot water.

Survey figures secured show that the average consumption of coal for the operation of greenhouses in this state runs about 10 tons (bituminous) per season per 1000 square feet of ground covered. This figure will not apply alike for all ranges, since the amount of fuel used will depend on the grade of coal, type of house, tightness of construction, severity of the season, efficiency of heating system, capability of fireman, and crops grown.

Oil burners have replaced coal furnaces in some greenhouses in Pennsylvania and other states and are likely to attract further attention in the future.

The following table shows the relative use of different methods of heating in 100 Pennsylvania vegetable forcing greenhouses:

TABLE I.

Heating Systems Used in Pennsylvania Greenhouses

Heating System	Ranges 10,000 square feet or less in area	10,000 to 20,000 square feet area	20,000 to 40,000 square feet area	40,000 to 60,000 square feet area	Above 60,000 square feet area	Total
Hot air -----	3					3
Hot water -----	35	8	5	1		49
Steam -----	10	13	15	4	6	48
Total -----	48	21	20	5	6	100

An interesting point relative to the location of heat pipes is brought out by a New Castle grower. At one time the heat pipes in his large houses were placed at a height of 6 to 7 feet above the ground in order to give plenty of head room for all greenhouse operations. Lettuce diseases were very serious then throughout the winter. The heating pipes were lowered to just above bed level and there has been little trouble from disease since that time. The difficulty was undoubtedly corrected through the securing of a better circulation of air after the heat pipes were lowered.

GREENHOUSE SOILS OF MANY TYPES

Most of the soils in vegetable greenhouses cannot be said to belong to any particular class since they may have been modified in various ways until they no longer even slightly resemble the soil that was originally used. This is particularly true of course where the soils are built up and improved annually rather than changed every year or two. The greenhouse man attempts to establish the most perfect soil conditions possible in order to secure maximum returns from his heavy investment. In thus building up his original soil he may change its structure through the addition of sand, lime and manures; its color will become darker and its organic content increase as manure is added year after year; its texture is changed by the addition of quantities of sand; while manure and commercial fertilizers will quickly modify its chemical composition.

In spite of the fact that greenhouse soils may be modified in these ways, the person choosing a suitable location for this business should select a soil as nearly ideal as possible, in order that good returns may be secured the first years of operation, rather than securing only a limited income until the soil is built into condition suitable for favorable growth of greenhouse vegetables.

Vegetable greenhouses in Pennsylvania are found to contain many types of soils, the type depending largely on the location of the range and the materials that have been available for the modification of the soil. Thus in one section we may find a sandy loam, as in certain of the Erie houses, while in most of the Chester County houses the soil contains a high percentage of silt. The organic content in most of the greenhouse soils has been increased through the incorporation of large quantities of manure; or muck soil. In general it may be said that soils containing a good percentage of sand, and having a high organic content are most desired.

Greenhouse soils may run from six inches to two feet or more in depth, depending on location, whether benches or beds are used, and other factors. When benches or raised beds are used the depth is usually made 8 to 10 inches. In the case of ground beds the soil may often be deeper, taking the depth of the original soil of the location plus the materials that have been added from time to time. The deeper soils have the advantage of holding more moisture and therefore requiring less attention to watering. The shallower soils will grow just as good crops as deeper ones provided they are well prepared and cared for.

HEAVY MANURING IS PRACTISED

Frequent applications of plant food are necessary in the production of vegetables under glass. In no branch of agriculture is the ground cropped so heavily, the plants being spaced close to-

gether and one crop following another throughout the forcing season as soon as the smallest section of soil is vacant. A vegetable greenhouse represents a considerable investment, high returns are expected, and hence there is no stinting of plant food needed to grow optimum crops.

ANIMAL MANURES have been largely used in the past by the commercial vegetable forcer and as long as a supply can be procured, these are likely to be applied extensively in the future. Animal manures have been used to the exclusion of all other forms of plant food by many growers, and have been of great value not only because they add plant food to the soil, but because they promote physical and chemical changes in the soils through increasing the organic content. Of the various animal manures, horse manure has been used most extensively for vegetable forcing. It is more convenient to handle than cow manure and decomposes more quickly. Cow manure, though slower in action, is valued by many greenhouse men, particularly since this manure may be secured from city stock yards. Hog manure is used but is usually quite acid in character and may be the means of introducing plant diseases into the soil, particularly if sterilization does not follow its application. Railroad stock-car manures, consisting of a mixture of all kinds of animal manures, with a fair amount of straw, is now used extensively in the Northwest Pennsylvania section. Paunch manure, the digested and semi-digested materials removed from the stomach and intestines of slaughtered animals in the Chicago stock yards, has been largely used by Erie vegetable growers.

The rate of application of animal manure in Pennsylvania greenhouses varies from 20 to over 200 tons to the acre of ground. There seems to be a question whether applications above 40 to 50 tons per acre are in many cases economical. Larger amounts may be needed in a new greenhouse on fairly heavy soils until a good organic content is built up. Greenhouse soils sometimes run from 50 to 70 per cent organic matter, but excellent crops are raised in spite of their loose texture, and most greenhouse men believe that within reasonable limits, it is impossible to manure too heavily. The cost of the manure is probably one of the most important factors to be considered.

Green manures have not been largely used in the greenhouse because of the lack of time available to grow them. Continuous cropping is practiced under glass from early fall to mid-summer with just enough time left for sterilization and preparation of the soil for another season. The vegetable forcer cannot afford to leave his ground for any length of time in a non-cash crop. Quick growing green crops, such as rye, have been used successfully in some other states in rotations including spring tomatoes or cucumbers, by sow-

ing the rye seed between the growing crop plants, and turning under the consequent green growth when the tomato or cucumber plants have been removed. Such a practice provides some organic matter and results in economy of animal manures.

LIME AND COMMERCIAL FERTILIZERS ARE USED

Lime is used in most of the vegetable forcing greenhouses in Pennsylvania. It is probably of even greater value in the greenhouse than for outdoor market gardening, though for some crops, as melons, it has not proved of particular worth, and a few growers claim no benefit from its application, particularly where the soil is changed each year.

The amounts and types of lime used vary considerably among the different growers. Hydrated is probably the most common form applied since it is easy to handle and is quickly available, but ground limestone, burned lime, and marl are also used to more or less extent. Lime is commonly applied each year when preparing the ground for fall planting, though a few growers make two or three light applications per year and others may use this material only every other year. No definite recommendations for rate of application can be made, since soils will vary too much and amounts used will also depend upon crops and cropping systems. Growers may carry out crop and soil tests to determine the rate to use under their conditions.

More than 50 per cent of the Pennsylvania vegetable forcere have not used commercial fertilizers to any extent in the growing of greenhouse vegetables, but have depended entirely on animal manures to furnish the plant food necessary for the growth of crops. Doubtless where heavy applications of manure have been used, further additions of plant food applied in the form of commercial fertilizers might be wasted. However, with the scarcity of animal manures and their high costs, probably just as good results could be obtained through the use of commercial fertilizers as supplements to smaller amounts of manure, provided the soil is in good physical condition with a fair organic matter content; and since animal manures are deficient chiefly in phosphoric acid, fertilizers carrying this element would certainly be of value regardless of the amounts of manure used.

Nitrate of soda and sulphate of ammonia, both of which are quickly available for the use of plants, are the main nitrogenous fertilizers used. They are generally applied as top dressings to crops that seem to need stimulation of growth. Either the dry salts are scattered between the rows and worked into the soil in cultivation or watering, or they may be dissolved in water and applied as a liquid. In either case the applications are commonly fol-

lowed by clear water to wash off the plants any of the fertilizer that may have collected on the leaves. Since sulphate of ammonia is said to make the soil somewhat acid, some lime is applied to counteract too great acidity. Either of these above fertilizers are applied at the same rate as for outdoor vegetable growing or somewhat in excess of this. One pound to from 100 to 200 square feet of bed seems to be generally used.

Acid phosphate, containing 14 to 17 per cent phosphoric acid in quickly available form, is used at a rate varying from 500 pounds to two tons per acre annually. Various super-phosphates containing higher percentages of phosphoric acid are coming into more general use, while raw rock phosphate is applied to some extent. Growers may compost the latter with the animal manures that they plan to use in the greenhouses.

Of the potash carriers, wood ashes seem to be most largely used in Pennsylvania. They contain at best but 5 to 8 percent potash, but they also have a high lime content. Wood ashes are often not easy to obtain in large amounts, since few manufacturing firms use wood as fuel. A good deal of this fertilizer is imported from Canada.

A few growers prefer to use complete fertilizers, either mixed at home, or made up to order by fertilizer firms. As a rule these are applied after spading or plowing and previous to the final preparation of the soil for planting. One grower near Altoona, however, applies a light dressing of complete fertilizer in the preparation of the soil for each crop, and others make two applications a year. No fertilizers of definite analysis are used by all growers, but high grade materials are usually applied, such as 3 to 5 percent nitrogen, 8 to 10 percent phosphoric acid and 3 to 5 percent potash. Amounts used vary greatly but in general larger quantities are used than in outdoor vegetable growing. A Mansfield grower uses about 2 tons of bone meal and an equal amount of acid phosphate annually for a range covering 20,000 square feet of ground. These amounts are considerably in excess of the average applications, and there would seem to be danger of over-supply of certain elements, and consequent toxic condition of the soil, if long continued.

Some vegetable forciers vary their fertilizer practice from year to year, using for example bone meal as a source of phosphoric acid one year, acid phosphate another, and tankage the third. They believe that such procedure tends to decrease the damage to the plants through the accumulation of excessive amounts of any particular material.

SOIL STERILIZATION PREVENTS TROUBLE

The sterilization of greenhouse soil is practiced by many of the growers of the state. All do not consider sterilization necessary, some having used their soils continuously for 10 to 15 years with

no special treatment for diseases other than practicing strict sanitary measures such as the removal of crop remnants. The majority, however, who do not change their soils every year or two use sterilization as a means of insurance against serious outbreaks of pests and diseases. As a rule, sterilization is practiced every other year, though an occasional grower sterilizes every year and others sterilize only when they believe it absolutely necessary.

Steam and the formalin drench are the two sterilization methods in use in Pennsylvania. They are usually carried out during the late summer, after the spring planted crops have been harvested and previous to the planting of the first fall crops.

Formalin has little effect upon insects in the soil but will control most of the soil diseases. Nematode eggs are not killed by this treatment as they are by steam. In Pennsylvania formalin is used chiefly in flue heated or hot water heated houses where steam is not available.

The material is used at the rate of 2 to 4 pints of 40% commercial formalin to 50 gallons of water. One gallon of this solution is applied per square foot of surface. Watering cans, barrels with certain attachments, sprayers, and special apparatus are used to apply this material. The watering can method is too slow to be economical and the grower should devise some quicker system suitable to the size and arrangement of his greenhouse. When the beds are treated with formalin, the walks, tools, walls of the house, and benches or sides of raised beds should also be sprayed with the solution. In case of steam sterilization, formalin may be used as a spray in the way just mentioned to make sure of eliminating as far as possible, all diseases from the house. At prices prevailing during 1924 for 40% formaldehyde solution, the cost of materials for the formalin drench would be from one to two cents per square foot of ground covered.

STEAMING APPARATUS. Various devices are used for the steam sterilization of soils in greenhouses. They include a box or compartment in which flats filled with soil are placed. In the bottom of the box is run a pipe perforated with small holes, through which the steam penetrates the enclosure and sterilizes the soil in the flats. One firm is so successful in eliminating diseases through this sterilization of seed and plant flats and by sanitary measures, that no general sterilization of the soils in the greenhouse beds has been necessary. One grower in Pennsylvania has also avoided disease in the crop beds by sterilizing the plant growing soil with boiling water.

Galvanized iron pans are considerably used by Pennsylvania growers for sterilization of the soil in the greenhouse beds. The larger ranges use several of these pans at the same time. In flue

heated or hot water heated houses the steam may be supplied by a portable engine. The perforated pipe device is used by some of the largest growers and seems especially desirable for sterilizing of large areas. The steam rake or steam harrow is not used in Pennsylvania. Only one grower has reported a greenhouse equipped for tile sterilization, yet this system is probably the most efficient in elimination of soil diseases and insects, and less labor is required for its operation. The main objection to tile sterilization is the cost of installation.

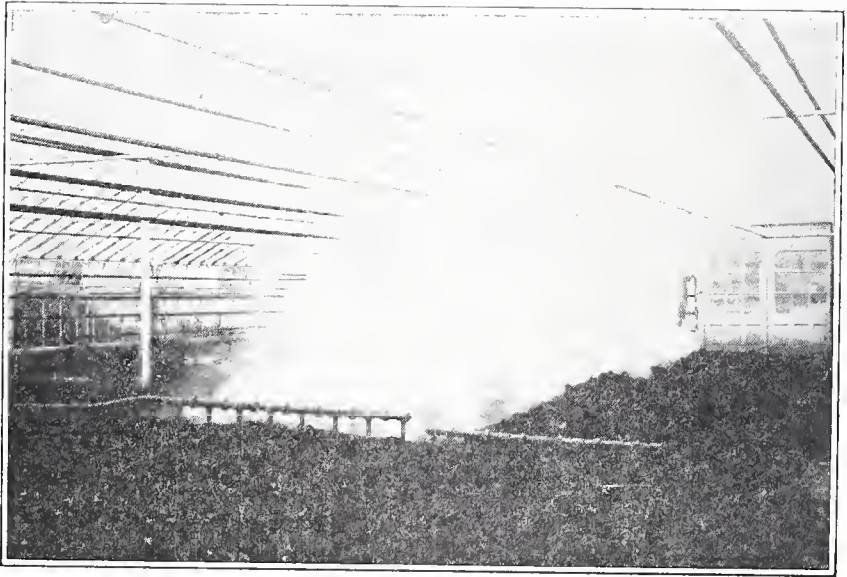


Fig. 6. Sterilizing greenhouse soil by the buried perforated pipe method, Erie, Pa.

OTHER METHODS. Hot water Sterilization is not used in Pennsylvania except for the treatment of soil to use in growing plants. The method for crop beds consists briefly in forcing boiling-hot water under pressure into the soil. Nematodes are eliminated by this treatment as well as other pests and diseases, but objections raised to it are the labor involved in applying the water, and the danger of puddling the heavier types of soils.

There are a few growers in Pennsylvania that allow their soil to entirely dry out during the period between the harvesting of the last summer crop and the planting of the fall crop. Extensive experiments in the other states have shown this practice, known as dessication, to be undesirable. A better plan is to keep the soil in good condition through the application of a summer mulch of manure which is kept moist at all times.

The practice of freezing the soil to eliminate insects and diseases has been followed by some growers, particularly in the New Castle section. In such cases all heat is shut off and the houses opened

wide for a period of 4 to 6 weeks between the first and second crops of winter lettuce. The freezing of the soil will destroy some insects in the greenhouse soil, just as would be the case in the open field, but whether it will have the same effect upon diseases is questioned. Many diseases will probably go into a resting stage and will recover activity when normal temperatures are restored.

The economy of closing down the greenhouse in mid-winter is also questioned. The cost of steam sterilization during the summer when there are no crops in the houses must be balanced against the loss of an extra crop that could be grown during the period in which the soil is exposed to freezing.

Of 80 growers reporting, 21 used steam sterilization of greenhouse beds, 8 formalin sterilization of the beds, 2 sterilized plant growing soil only, one by steam, one by hot water, 2 had practiced freezing, 20 were able to control diseases by preventive and sanitary measures only, while the balance, practically all of whom were equipped with benches, changed their soil every year or two.

OVERHEAD IRRIGATION SAVES LABOR

As most vegetables contain a high water content and much moisture is therefore needed to produce the high quality demanded of greenhouse edibles, the labor involved in watering becomes an important factor in profitable production. A good deal of this operation in small greenhouses and those in which benches are used to grow the crops is still done with the hose. In the larger ranges with ground beds, however, practically all houses are equipped with overhead irrigation.

The only objection of note offered to overhead irrigation in the greenhouse is that dealing with disease. There is some foundation for this complaint, since diseases do as a rule thrive in a humid atmosphere such as is provided when using overhead irrigation systems. The main trouble seems to occur with the tomato crop but diseases can be avoided to a large extent by watering the tomatoes only on sunny mornings and on a rising temperature so the plants will dry off before night. Cucumbers are favored by humid conditions such as may be provided through the overhead system and lettuce seems to suffer little from the sprinkling system from above. In fact lettuce is no doubt benefitted on hot days in early autumn or late spring by the "shower" which will lower the temperature of the house many degrees. Sub-irrigation has none of the undesirable features of the overhead irrigation but has not proved popular because of the cost of installation and the greater difficulty of putting in the system so it will operate with entire satisfaction. Also the sub-irrigation water is colder when it reaches the roots of the plants than is the case with overhead irrigation.

The factors that are considered in selecting a method of watering for the greenhouse are cost of installation, upkeep expense, labor needed for operation, effect on size and quality of crop, mechanical injury to plants, effect upon soil, uniformity of watering, and effect relative to crop diseases.

INSECTS AND DISEASES ARE CONTROLLED

The methods of controlling specific insects and diseases in Pennsylvania vegetable greenhouses are mentioned under notes on the more important crops. The ideal growing conditions provided under glass are favorable not only to the crops but also to the development of troubles that often become serious if not checked. Comparatively little spraying or dusting are carried on though both are coming into more common use. Preventive measures, however, are used by all growers regardless of what else may be done along this line. Some of these may be mentioned as follows: use of clean seed; use of clean soil and manure, or the sterilization of same before cropping; resistant varieties of vegetables; stocky, well-grown, clean plants; roguing of infected plants; removal of trimmings and crop remnants from greenhouse; elimination of weeds in beds and walks; careful regulation of watering, temperature, and ventilation to further healthy, vigorous growth; fumigation at regular intervals and rotation of crops.

MARKETING NOT SERIOUS PROBLEM

The production of greenhouse vegetables in Pennsylvania is not large enough to present serious problems in marketing. The important commercial producing areas are quite close to the larger cities which absorb the bulk of the forced vegetable supply. The numerous smaller cities and towns form very convenient and satisfactory outlets for the many small greenhouse plants scattered over the state. Marketing methods for the various forcing vegetables are briefly stated in the comments on the individual crops that follow.

LETTUCE IS MOST IMPORTANT FORCING CROP

Lettuce is without question the most extensively grown forcing crop in Pennsylvania. Practically all the greenhouses in the state grow lettuce at some season of the year, with the exception of those in the Kennett Square section, while the frame growers in the southeastern part of the state have counted lettuce as one of their main crops.

The reasons for the importance of lettuce are probably as follows:—There is a strong demand on all markets for lettuce during the fall, winter and spring months.

The crop is more easily grown in the dull days of winter and in poorly built houses than tomatoes, or cucumbers.

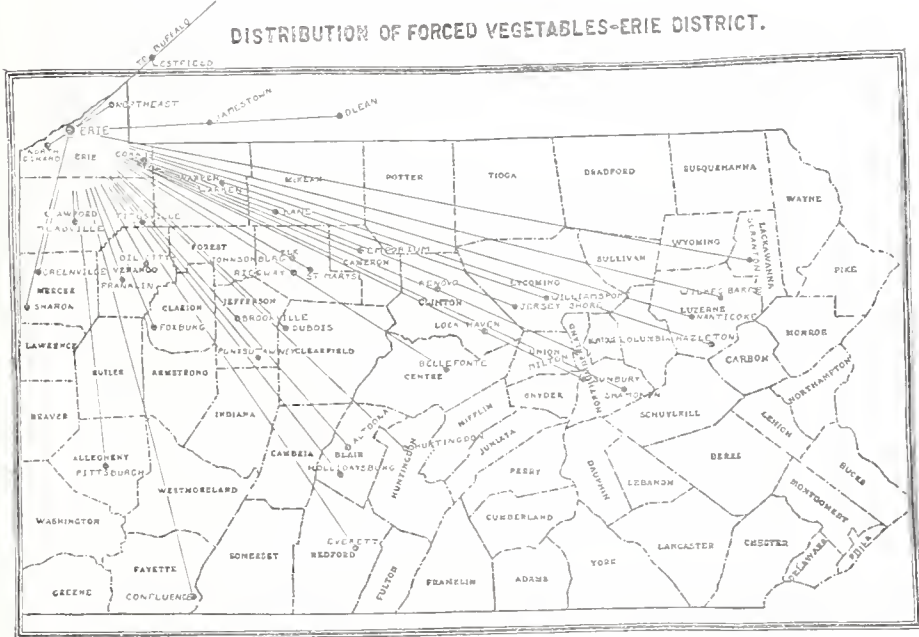
Lettuce can be grown as an early winter crop, planting at any convenient time while winter tomatoes or cucumbers must be started in summer to get good yields. This point is of chief importance to the owner of a small greenhouse range, who is interested in trucking outdoors, and must get his field work cleaned up before starting operations in the greenhouse.

Lettuce requires less heat and less attention than most other forced crops.

Lettuce will thrive on a variety of soils and will bring some returns even on the comparatively poor soils that may be present the first year or so that a greenhouse is operated.

It has been possible until recently to sell the crop at a fair price, satisfactory to the consumer, and yet bring a reasonable return to the grower. California and Southern head lettuce of the dark Iceburg type now presents strong competition to Pennsylvania grown leaf lettuce, especially in the larger markets, and has much influence on the returns secured.

Fig. 7.



COMPANION CROPS

Lettuce lends itself admirably to culture as a companion crop. During the winter it has sometimes been companioned with late Sown New Zealand spinach; with cauliflower planted to mature at the holiday season or in early spring; or with spring tomatoes or cucumbers, the lettuce transplanted to the beds at the same time

as these crops and removed in 4 to 6 weeks when the cucumbers and tomatoes will need the entire space. The last two systems are not the most desirable since lettuce does not thrive under the high temperature needed for tomatoes or for cucumbers, nor do the latter grow so well under lettuce temperatures. None thrive best at a mean temperature.

As a rule lettuce is grown alone during the fall and winter, two or three successive crops being followed by tomatoes or cucumbers in the spring, these latter vegetables possibly being interplanted with lettuce; in many small ranges winter lettuce is followed in the spring by vegetable plants grown for field setting.

VARIETIES

The only variety of lettuce grown in the greenhouses of Pennsylvania is Grand Rapids, a loose leaf type. Growers have not had success in growing head lettuce in our greenhouses, due largely to tip burn and light weight heads; for that reason and the fact that leaf lettuce grows more quickly and with much less care than head lettuce, the Grand Rapids is firmly established in the estimation of the grower, and since it is of good quality, attractive in appearance, and there is little waste in its preparation for the table it also appeals to the consumer. There are now two strains on the market, a light green and a dark green strain. The former is preferred by the consumer because of its more attractive appearance and possibly finer quality, consequently it is much more extensively grown than the dark green. The dark green type has the merit of attaining greater weight than the light green in the same length of time, especially during the dull days of late fall and winter.

Head lettuce has been grown extensively in the frame sections, as discussed under frame forcing. If a strain of some variety of head lettuce could be produced that would mature solid heads of good size in the greenhouse in about the same period of time as is necessary to produce good leaf lettuce, also being immune or resistant to tipburn, a great benefit would be derived by growers.

The majority of the lettuce crop is raised in flat beds. In some ranges the beds are raised 8 to 12 inches, as heretofore described, and in a few smaller houses, benches are used for growing this crop. The latter are not desirable except in special cases.

REQUIREMENTS

Leaf lettuce will grow on many types of soil but thrives best in one rich in organic matter and food materials, and containing enough sand to work easily and dry off quickly on the surface. Cos and Head lettuce are more exacting in their soil requirements. Growers in Pennsylvania have used various soils as a base for the

greenhouse soils they have built up for lettuce growing. One firm has a gravelly loam and a loam of heavier type on its farm, and both have been used for greenhouse lettuce beds but characteristics have been much modified by the addition of manure, so that little trace of the original types remains.

Most growers fertilize lettuce only through heavy applications of manure, made in the fall shortly before the first crop is planted, and repeated between the second and third crop if such addition is necessary. After a soil is built up, the fall application is generally enough to carry three crops of lettuce then a second application of manure is sometimes made before planting the tomato and cucumber crops. The mulch often used with the two crops named or a summer

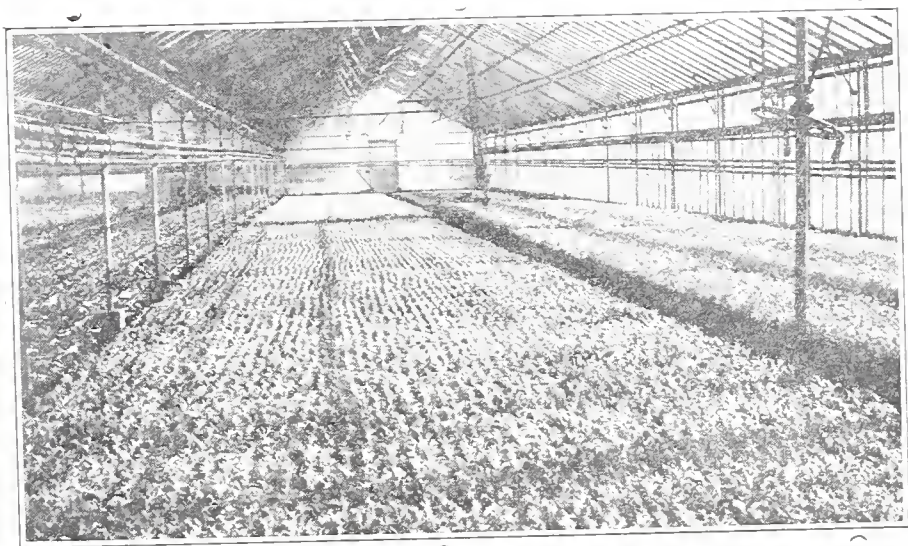


Fig. 8. Lettuce plants of various sizes grown in one greenhouse, later to be transplanted to adjoining crop houses.

mulch of manure that is sometimes applied also help to add fertility to the lettuce soil for the following season. Occasionally an application of nitrate of soda or other quickly available nitrogen carrier is made to the lettuce crop to hasten growth. A few growers also add a sprinkling of bone meal at the time of soil preparation. Some fertilizer carrying phosphoric acid is desirable to make up for the lack of this element in the manure used. Lime is commonly applied annually just after the beds are spaded or plowed and before sterilization, and worked into the soil before planting. Growers use at least one ton per acre of ground covered.

Leaf lettuce grows best at temperatures ranging from 45 to 50 degrees at night or on cloudy days and ten to fifteen degrees higher on sunny days. Some Pennsylvania growers allow even higher temperatures than this to hasten growth but there is then greater care needed in watering and ventilation, with more danger of disease.

INSECTS AND DISEASES

The chief lettuce troubles reported from Pennsylvania greenhouses include Drop, Damping off, Tipburn, Rosette, Cabbage loopers, and green aphid.

Diseases are kept under control by sterilization of soil and other preventive measures. Cabbage loopers are troublesome only on the fall crop, and are controlled to some extent by hand picking. Fumigation with cyanide would be less laborious and more effective. Tobacco or cyanide fumigation controls the aphid. Dusting with nicotine dust is used in a few cases for aphid and will help to control the loopers.

Leaf lettuce stalks will weigh anywhere from 4 ounces to over a pound at cutting time. A pound per square foot of bed space is considered a paying yield. Prices secured will vary with the time of season and from one year to the next. Ordinarily they run from 50 cents to \$1.25 a five pound basket. Where, because of head lettuce competition, the returns from greenhouse leaf lettuce do not justify its production, the growers are changing to substitute crops.

PACKING AND MARKETING

Little has been done in the grading of leaf lettuce, except that growers generally cater to the preference of most markets for the light green type. There seems to be less chance for grading to be of great importance than is the case with most crops.

In the Erie section the lettuce is packed dry into the baskets, weighed, and "dipped" to keep it fresh until it reaches market destination. The package used by the Erie growers for all forced products is the so-called "twelve quart splint" basket of either the Eureka or square-weave type or the diagonal weave. There is need for further standardization of this package as samples used for official testing have indicated that many baskets hold more than the supposed capacity. The forced vegetables however are all sold by weight rather than by measure. On all shipments and most local sales the baskets are given away with the purchase.

In packing the basket for shipment, it is first lined with paper in various ways, five pounds of lettuce put in, and a wooden veneer cover tied on. An additional paper wrapper is used for mail or express shipment. Some of the growers in winter place four baskets together as shown in Figure 9 and wrap the whole with a special heavy paper which serves to keep the lettuce fresh by preventing evaporation of moisture and also reduces the danger from freezing while in transit.

The larger and better established Erie growers ship a large part of their lettuce out of town to nearly 50 small cities and towns of northwestern Pennsylvania and western New York. This is a di-

rect-to-retailer method and the prices are quoted by the grower before the shipment is sent.

Express shipment is used to most of these markets, parcel post being popular to only a few places. The smaller growers sell chiefly in Erie, some to wholesalers, some to retailers and hucksters and others sell at retail themselves, either at market or through a special trade. Surplus lettuce is usually shipped to Pittsburgh for sale on commission but the direct distribution to the retailer is the most important and profitable method of marketing.

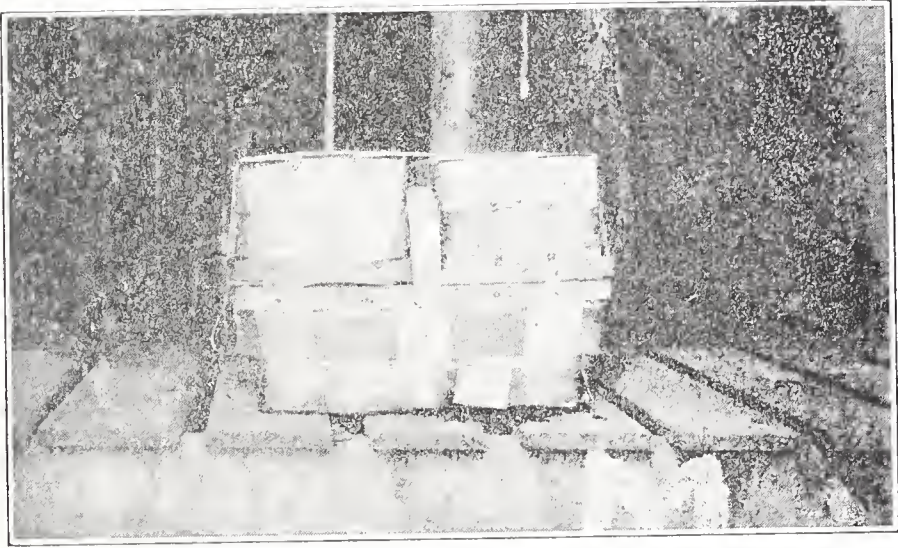


Fig. 9. Side view of 4 basket lettuce package from Erie district tied for express shipment. Each basket contains five pounds of lettuce.

There is not so much uniformity in marketing methods in New Castle as in Erie. The packages are of the same type, the splint market basket with one handle. There is a difference however, in the size of the basket and in the quantity of goods packed. As a general rule the trade in New Castle and the surrounding towns demands five pounds of lettuce packed in the twelve or fourteen quart basket. Pittsburgh and Beaver Falls demand but three pounds in a basket. The one or two men who ship to Youngstown, Ohio, have to use a fourteen quart basket to meet the demand there. These baskets are all of the square cornered type whereas Erie growers use both square and round cornered baskets.

Throughout the section two thirds of the lettuce is sold in New Castle and the remainder chiefly in nearby towns. In packing wet lettuce for market the growers allow one pound for the basket and one-half pound for the water. Express is the method of transportation used except where delivery can be conveniently made by the dealers truck. Occasionally surplus is shipped to Pittsburgh on commission.

The direct-to-retailer method of sale is the most popular although considerable stock is distributed by New Castle wholesalers.

During the war the New Castle Gardner's Association was organized and cooperative shipments were made to Pittsburgh, but this was discontinued several years ago. Conditions for shipment are not as favorable as at Erie, because of the routing of transportation. However, as the production is smaller and local consumption is greater, the outside distribution is not as important as at Erie.

Most of the numerous greenhouses scattered over the state outside of the main forcing sections cater primarily to local markets. Marketing is not a serious problem under such conditions, as the supply is rarely larger than the demand. As a rule the larger growers sell directly to retailers and wholesalers, while the smaller producers quite commonly use retail markets or in some cases a house to house trade. Methods vary in different sections, but a quite general practice is to ship any considerable surplus to larger markets on commission rather than to disturb local markets by changes in prices. Lettuce is perhaps the only crop in which surplus is a problem.

The packages used include most anything that can be picked up, the only outstanding feature being the large proportion of second hand containers in use. This applies to other forced vegetables as well as to lettuce. Close contact with the consumers has naturally offset the need for an attractive package. Where increased competition develops, the question of suitable and attractive containers should be given early consideration to increase possible sales.

COMPETITION

In Pittsburgh and the smaller markets that Pittsburgh supplies, the Pennsylvania leaf lettuce meets two types of competition; that of Ohio greenhouse leaf lettuce and that of California dark Iceberg type. The latter is the strongest competitor. The California growers with their standard packages and well graded, good quality stock shipped under known brands have created a demand for Iceberg that must be seriously considered in any plans for expansion of greenhouse lettuce growing in Pennsylvania. The leaf lettuce from Ohio does not offer a great amount of competition because of its poor shipping quality.

TOMATOES ARE GROWN IN EVERY SECTION

Tomatoes rank second only to lettuce as a Pennsylvania forcing vegetable. Probably as great an acreage in the state is planted to cucumbers but more growers are interested in tomatoes. The survey records show a total of seventy greenhouse men who grow tomatoes either as a fall and winter crop or as a spring crop or both.

There is no doubt that the tomato is one of the most difficult of forcing crops to produce successfully year after year. This is particularly true of the fall and winter crop, when lack of sunshine and consequent trouble with watering and ventilating during the cold months encourages the development of serious diseases. At that season too, close attention to pollination is necessary in order to obtain a fair setting of fruit. Insects, especially white fly, are more troublesome during the winter months than in the spring.

Nevertheless, though the spring crop is much easier to grow, and produces a larger yield, at that time of year, the grower faces competition from Southern field grown tomatoes. With this factor in view and the higher prices received for winter tomatoes, many forciers in certain sections have given particular attention to the crop at that season. The competition of outdoor grown head lettuce with our greenhouse leaf lettuce has had some effect in turning growers attention to a more profitable winter crop such as tomatoes. though recently western tomatoes are being shipped in to compete with our winter crop.

CROP ROTATION

The tomato fits into many rotations and this explains partly its popularity. The commonest rotation used is lettuce in fall and winter followed by spring tomatoes. Two crops of tomatoes may also be grown, the spring crop closely following the one planted in the fall. Radishes, cauliflower, New Zealand spinach or other cool crops might be substituted for lettuce in the rotation mentioned. In the Southeastern Pennsylvania section rotations of flower crops with tomatoes are used.

One grower states that by using chrysanthemums in the fall rather than sweet peas, he can get his spring crop of tomatoes planted early and thus command higher prices for the earlier crop. In comparison with growing tomatoes throughout the season, the spring crop following that in the preceding fall and winter, the chrysanthemum-tomato or sweet pea-tomato rotations have the advantage of avoiding trouble with tomato diseases that are particularly prevalent in fall and winter. One firm in Montgomery County uses tomatoes (fall) followed by canteloupes (spring).

A Danville grower has inter-planted his roses with tomato plants in the spring. For the time being the tomatoes must compete with the roses. Later when the latter are cut back and dried off, the tomatoes get more room, and though a large yield is not obtained, an extra crop is produced when the benches would ordinarily not be giving any return.

TYPE OF HOUSES AND BEDS

Tomatoes are grown in many types of houses, the type depending more on the location and lay of the land than on the crop grown.

In New Castle, where some large houses are built on steep slopes, the uneven span house is used. One range at Kennett Square built on a slight slope, is likewise uneven span. The growers who have built on level land, as a rule use the even span house. The greater the amount of sunlight admitted, the better should be the results with tomatoes. This crop does not thrive best in old, dark houses, or houses with dirty glass, types that exclude a great deal of light. We find in Pennsylvania, tomato growers who are using benches for this crop, others who have raised beds and many of the larger greenhouses have flat or ground beds. Benches are used principally in cases where tomatoes are grown through the fall and winter. At this time of the year, the bottom heat that may be given to bench tomatoes helps to hasten maturity and increase the yield.

Raised beds are desirable in certain greenhouses where the soil is poorly drained. Where the soil is well enough drained to use ground or flat beds, this type is preferred, since spring tomato yields on beds are greater than on benches, and the cost of upkeep is small as compared with either wooden benches or raised beds with wooden sides, while the initial cost of building concrete benches or raised beds with concrete sides is considerable.

VARIETIES

There are a great many varieties of tomatoes grown in Pennsylvania greenhouses, the reason for such a number probably falling under the following heads:

1. Personal preference of grower for variety with which he has been successful.
2. Demands of market for certain size or color.
3. Variation in seedmen's strains of the same variety.
4. Improvement by the grower of certain varieties by selection of **own seed**.
5. Some varieties more desirable for winter growing, others for **spring crop**.

A good forcing tomato should possess the following characteristics:

Size and color demanded by market.

Adaptability to season grown.

Early maturity.

Large yield.

Abundant foliage.

Plant resistant to disease.

Well shaped fruit, free from sutures or cracking, flesh tender, firm, juicy, fine texture, good quality.

There are two general types of forcing tomato, the English and the American. The former differs from the American type in having smaller leaves, smaller and more uniform fruit with greater number of fruits to the cluster, and requiring less attention to pollination. As a rule the English type is more popular where the market demands a small fruit, and is more largely grown as a winter tomato since at that season the small fruit is in greater demand because of the high price per pound asked for it. The English type is well represented by the Comet variety, which however, has been increased in size by selection, and the American type by the Bonny Best and the Globe.

The varieties grown in Pennsylvania arranged approximately in order of importance at present follow :

BONNY BEST.	Large red fruit. Popular for fall, winter and spring crops all through state.
GLOBE,	A large, pink tomato, grown chiefly as a spring crop. Popular in the New Castle section.
COMET.	Fruit small, red, solid, uniform. A desirable winter forcing type, grown almost to the exclusion of all others in the Kennett Square section.
LORILLARD,	One of the oldest American greenhouse tomatoes still used by a few growers who have improved the original type by selection.
MARVEL,	a variety developed for resistance to Wilt is attracting the attention of growers who have been troubled with this disease in their greenhouse tomatoes.
JOHN BAER,	and CHALKS JEWEL are varieties similar to Bonny Best and are considered desirable by a few men who grow them.
GRAND RAPIDS,	is a variety similar to Comet that produces many small fruits to the cluster.
IDEAL,	a new forcing variety somewhat larger than Grand Rapids, is being tried in Pennsylvania.
SUTTON'S FORCING	(English) Lord Roberts (English), of which there is now an improved selection known as Peerless, Stirling Castle (English), Stone, and Beauty, are all used by one or two growers. All but the last named are red.

There is a difference of opinion among greenhouse tomato growers regarding the raising of seed from plants grown in the open vs. plants grown in the greenhouse. The supporters of the latter plan claim that field grown plants are more likely to be diseased than those grown under glass and that many of the diseases are transmitted through the seed; another point they advance is that seed

from greenhouse grown plants will produce plants better adapted to greenhouse conditions than seed from field grown plants. Many reliable seedsmen now carry special strains of tomatoes for forcing. The tomato is one of the easiest plants to improve by selection of seed from plants showing desirable characteristics, and many Pennsylvania greenhouse growers have taken advantage of the fact. There is still a possibility of development of better tomato varieties for the greenhouse, especially along the lines of larger yield and disease resistant plants.

SOIL PREPARATION AND FERTILIZATION

Many types of soils are used in growing greenhouse tomatoes, ranging in texture from those containing a predominance of sand to the heavier clay loams and silts. The Erie growers have used beach sand to lighten their soils, while the Kennett Square growers have as a rule fairly heavy loam. All greenhouse soils are so changed, however, by the addition of organic matter, and often sand, that their original characteristics are soon lost. Suffice it to say that good yields of tomatoes are being secured on any of these soils that are sufficiently well drained and fertilized, though lighter soils always have advantages.

There is great variation in practice as far as preparation and fertilization of the soil for tomatoes is concerned. Many of the most careful growers sterilize the soil with steam once every year or two, to get rid of the many diseases that attack this crop. Others, who have not been so much troubled with diseases, do not sterilize, but are careful to remove all tomato plant remnants when pruning or when tearing out the old plants. Where the crop is grown on benches, the soil is renewed every year or every two years so that no sterilization is necessary if the soil is secured from a place where tomatoes or related crops have not been previously grown.

Most growers agree on two practices; one, a heavy coating of manure of some sort spaded or plowed under immediately preceding the tomato crop; and a mulch of manure applied around the plants either just after planting or after the first hand of fruit has set. Some tomato forcers who precede the spring crop with three crops of lettuce, add no further manure to the soil than the amount turned under before the first lettuce crop the previous fall. This will, of course, depend upon the condition of the soil in question as to fertility and texture. The type of manure used will vary with different growers, and the same plan may not be followed season after season. The scarcity and high price of manure often make certain changes advisable.

A manure mulch is usually applied after one to three hands of fruit have set. Earlier applications are looked on with some dis-

favor if there is much fertility in the manure used since too vigorous growth of vine would be stimulated at the expense of fruit production. If the tomatoes are inter cropped with lettuce, early mulching is impossible. Where fresh manure is used, the mulch is soaked with water immediately after it is applied to the beds, so that the plants may not be burned by the ammonia fumes rising from this manure. In the mushroom districts, the spent compost from the mushroom beds is extensively used as a greenhouse tomato mulch. Some growers find that manure mulching requires too much labor and prefer to apply plenty of manure preceding the planting of the crop, and practice light cultivation instead of the mulching until the vines so shade the soil that further cultivation seems unnecessary.

The use of fertilizers for the tomato crop varies as much in practice as the use of manures. Some growers depend entirely on manures to furnish the needed nourishment for the plants. Dried sheep or poultry manure may be used after the first fruits have set, or earlier if the soil is so deficient in food that the tomato plants seem to lack vigor. Nitrate of soda is used for similar results, applying dry between the plants at the rate of 100 to 200 pounds to the acre.

Other growers use tankage, one ton or more per acre, bone meal one to four tons per acre, acid phosphate two or four tons per acre, raw rock phosphate, or wood ashes, any of these being applied either just before mulching or when the soil is prepared for the crop. There seems to be little doubt that a phosphoric acid fertilizer will benefit the plants and probably hasten the maturity of the fruit. Lime is also used extensively, before the first fall planting, growers applying each year from one to three tons per acre, or 5 to 15 pounds to 100 square feet.

One firm growing winter tomatoes on benches reports the following interesting practice:—

1. A heavy application of horse or cattle manure is given the outdoor area from which soil is to be secured for the benches. This is plowed in and harrowed well. The mixture is then taken to the benches, on which it lies six inches deep.
2. A mixture of 100 pounds dried cow manure and 100 pounds dried sheep manure (commercial goods), and 50 pounds poultry manure (local supply) is used on benches in each of larger houses 22' x 135', and mixed with the surface soil before tomato plants are set in the fall.
3. An application similar to above when first hand of fruit has set.
4. Same treatment repeated after third hand has set.
5. When the first crop is done, the ground is limed with 150 pounds hydrated lime to each house, and is then spaded. Chief

aim of lime said to be to control disease. The tomato plants for the spring crop are set out and an application of the dried manure mixture is made. When warm weather comes a mulch of spent mushroom manure is added.

GROWING PLANTS

For the fall crop of tomatoes, the seed is sown from June 15th to July 15th, for the spring crop from December 1st to January 15th or later, this date depending largely on the preceding crop of the rotation. In the case of winter tomatoes, it is desired to give the plants an early start and get fruit set before the dull days of early winter. The spring tomatoes are borne in more favorable weather from May to August. The planting date will also vary with the earliness of the variety used, with market demands, and the temperature used.

Two to three months from the time of seeding the plants are placed in the crop beds. Two to two and a half months later the first tomatoes should be harvested. A firm in Montgomery County, sows seed for the fall crop July 15th, pricks out the seedlings in two weeks, transplants to benches September 1st, and by the last of October starts picking the crop.

In the Kennett Square section, there is a practice among growers who raise tomatoes the year round on benches to at first replace only the inner rows of first crop tomatoes with the spring crop plants. Meanwhile, the outside row plants that have been in the benches since the previous fall continue in bearing until the new plants are ready to bear—thus assuring a continual crop. Later the remainder of the old plants are removed and replaced. This method is not favored by all growers however, one progressive Italian there declaring that he believes he gets larger crops if the benches are entirely cleared off before the spring crop is planted.

PLANTING DISTANCES. Many planting distances are in use for tomatoes. The plants may be set anywhere from 12 inches to 2 feet in the row from 20 inches to 4 feet between rows. Much depends upon the interior arrangement of the house, the variety used and the season when the crop is grown. Where raised beds and benches are employed, the plants are usually set closer together since easily reached from the walk, such distances as 18" x 20", 18" x 24", 24" x 24". New Castle and Erie tomato men who use ground beds largely, allow greater space between the rows, as three feet, for convenience in getting through for culture and harvesting, but set the plants closer in the row, as 12 to 16 inches. The closer planting probably results in smaller fruit and smaller yields per plant but the same or greater yield per square foot of ground.

INTERCROPPING

The spring crop of tomatoes may be intercropped with lettuce, radishes, vegetable plants or other quickly maturing crops. Since lettuce and radishes require lower temperatures than tomatoes for best growth, a temperature favorable to tomatoes is not favorable for the intercrop. Intercropping also crowds the tomatoes and probably somewhat retards the maturity of the fruit, as well as making it difficult to prune and tie up the plants.

PRUNING AND TRAINING

Greenhouse tomatoes are generally trained to one stem, though a few Pennsylvania growers train to two stems. The two stem system is mainly used where the greenhouses are small, with low roofs, and therefore with the one stem training, the plants would touch the roof before the desired number of clusters were set. Some growers in Kennett Square who raise tomatoes on benches, train the plants first to binder twine fastened above to overhead wires. As the plants become tall, the lower fruit matures, and the upper fruit gets out of reach, the plants are bent over, the lower part of the stems tied in a reclining position to horizontal wires running lengthwise of the benches a few inches from the ground surface, and the tops of the plants are bent upward again and supported on vertical cords of binder twine further along the row. (See figure 10)



Fig. 10. Method of training tomato vines used by some growers in Kennett Square Section. (see text)



Fig. 11. An excellent crop of early spring tomatoes, Globe variety, on raised beds at Kennett Square.

The common method of supporting tomato plants is by binder twine fastened above to overhead wires or to staples in the sash bars, and below tied about the stems of the tomato plants. The plants may be tied in four or five places to this support, or the cord or twine may be tied rather loosely so that the stems of the plants can be twisted about it as the plants increase in height.

WATERING, VENTILATION, AND TEMPERATURE

These three practices go hand in hand in the growing of greenhouse tomatoes. The soil for this crop is kept well moistened in order that steady growth may continue and plant food in the soil be made available. Too much moisture on the other hand tends to fast and spindly rather than steady and stocky growth, and consequent poor producing and weak plants. On benches, watering is usually done with a hose, but most of the Pennsylvania growers who have raised beds or ground beds save labor through the use of the overhead watering system. The Kennett Square men object to this system since the ground on which their houses are built is poorly drained, and the overhead system tends to make and keep the walks wet and sloppy. The overhead system through wetting the tops of the plants, doubtless encourages the spread of diseases, and should be used with caution.

Some growers prefer to water with hose after the blossoms set, in order that the pollen will not be washed from the blossoms, that a dry atmosphere may be kept, and thorough pollination will thus not be interfered with.

Good circulation of air is essential in tomato forcing. All Pennsylvania growers agree that stale, moist air, hinders pollination, favors disease, and helps to produce spindly plants. The plants should not be exposed to cold drafts of air, however, as checking of growth will likely result. Side ventilation, as well as top ventilation, is favored for tomato houses in order to secure good circulation of air, especially for the spring crop when high temperatures cause rapid transpiration of water from the leaves and quickly increase the humidity. The night temperature for tomatoes is generally kept at 60 to 65 degrees Fahr., with ten degrees higher on cloudy days, on sunny days from 80 to 90 degrees, and somewhat lower temperature when the plants are small. During the early summer months the temperature often rises above 100 degrees without injury to crops provided sufficient ventilation is given.

ARTIFICIAL POLLENATION NECESSARY

In the greenhouse, thorough pollination of tomatoes does not occur naturally, as it does in the field where insects and wind assist in the carrying of pollen to the stigma. The tomato flowers do not attract honey bees so this form of artificial pollination used under glass for

cucumbers, is not possible for tomatoes. Insufficient pollination of tomatoes in the greenhouse results in lopsided fruit or failure to set full clusters.

The English varieties pollenate more freely than the American types but some sort of artificial pollination is necessary to get a good set of well shaped fruit of any variety. Various methods are used. The most common practice among Pennsylvania growers is the jarring of the plants by tapping them near the flowers to be pollinated with a padded stick. Or if the plants are tied to upright wires the tapping of the wires will have the same effect. This method is not so thorough as passing from flower to flower and touching them with a camel's hair brush, or a brush made from a piece of ravelled binder twine fastened to a small stick. When conditions are favorable, pollen will adhere to such a brush and be transmitted from flower to flower. Still more thorough is the collecting of pollen grains in a shallow receptacle as a spoon or watch crystal, by holding the same under a cluster while the flowers are tapped with a stick, then bringing the stigmas of flowers in direct contact with the pollen collected.

Tomatoes pollenate most freely when the air and the plants in the greenhouse are dry and the sun is shining. Near noon on sunny days is the popular time to pollenate. Artificial pollination is practiced as soon as the flowers of the first hand are well developed, and thereafter on all favorable days. Because of the preponderance of cloudy weather in the fall, more thorough pollination is needed for the fall and winter crop than for the spring crop. In the spring as the earliest fruits brings the highest prices, great care is given to getting a good set on the first clusters. For this reason, some growers use the brush or the spoon method for the early pollination of the spring crop, and jar the plants later when weather conditions are more favorable to natural pollination.

YIELDS AND RETURNS

The yields of greenhouse tomatoes vary greatly according to cultural conditions, season, and variety used. Diseases, such as winter blight and mosaic, have considerable effect in reducing the yield. Because of lack of sunshine, and consequently poorer pollination, slower growth, and greater susceptibility to disease, the fall and winter crop produces less yield per plant than the spring crop. The yield for the winter crop will average generally from 3 to 4 pounds per plant, for the spring crop from 6 to 7 pounds. The yield per square foot, which really determines the returns, rather than the yield per plant, will depend on the planting distance used as well as the factors mentioned above. This should run at least one and a half to two pounds for the spring crop, with the fall crop one third to one half less.

One Pennsylvania grower reports a net profit from 15,000 square feet in spring tomatoes, including his own labor, of over \$3800. An Erie firm gives figures of 10,000 pounds in the spring season from a house 37 feet x 200 feet. In New Castle yields as high as twelve pounds each from plants of the Globe tomato have been secured but the average will run much lower. At Kennett Square a grower in the spring and summer of 1921 shipped 1800 ten pound baskets of Globe and Comet tomatoes from his range of 15,750 square feet.

The wholesale prices received from the fall crop have recently run from 25 to 45 cents a pound, while the spring crop will do well to average 15 cents. The average received for the latter will be determined largely by the time the crop is placed on the market. The earliest tomatoes may bring 25 to 30 cents a pound, but as the outdoor crop comes on the price will drop to 10 cents a pound and lower.

INSECTS AND DISEASES

The increase in the number and seriousness of tomato diseases in the last few years makes this vegetable one of the most difficult to grow in the greenhouse. The most important diseases now prevalent in Pennsylvania tomato houses are mosaic, winter blight (streak), leaf mold and fusarium wilt.

Mosaic and winter blight are the most serious diseases found in tomatoes and it is fortunate that they have not appeared to a greater extent. When once introduced, little can be done to control them except to keep the plants growing under the best conditions possible, to remove those badly diseased and to avoid spreading the diseases through pruning infected and then healthy plants. Steam sterilization of soil and treatment of seed with corrosive sublimate are used.

Careful watering and ventilation are essential in checking leaf mold. The disease is likely to cause most trouble in cool, cloudy weather. Thorough spraying or dusting of both upper and lower surfaces of the leaves with Bordeaux before the plants are set in the beds, and at frequent intervals as the plants continue growth prevents leaf mold to some extent. The wilts, for which no control has been found, are not common in Pennsylvania. Preventive measures, roguing of diseased plants and the use of resistant varieties are followed where wilts occur.

Whitefly, lice, nematodes and the large green tomato worm have been recorded as damaging the greenhouse tomato crops in this state. Fumigation with cyanide for whitefly, with tobacco or cyanide for lice, steam sterilization in the case of nematodes, and hand picking for worms are standard practices.

The following summary gives the methods used in Pennsylvania for the control of insects and diseases of greenhouse tomatoes.

Seed treatment.

Sterilization of soil.

Growing healthy plants.

Cleaning up refuse.

Proper control of watering, temperature and ventilation.

Spraying or dusting with Bordeaux.

Care in pruning.

Rogueing.

Fumigation.

Hand picking of worms.



Fig. 12. Winter Blight is one of the most serious diseases of greenhouse tomatoes.

MARKETING

At Erie 15 pounds of tomatoes are packed in the same package as is used for lettuce, the Eureka splint basket, and the same method of producer-to-retailer selling is used, with Pittsburgh as an outlet in case of glut. An attempt at grading tomatoes is made by some growers in Erie. The extra large tomatoes are packed separately for hotel trade. The remaining stock is separated according to the following grades: All perfect stock above $1\frac{1}{2}$ inches is put in number one grade, the rest of the good fruit goes into number two. In number two is also included some large stock, not perfect in shape. A third grade is made of the remaining rough stock not fit for number two grade. The last may or may not be salable depending on the condition of the market.

In New Castle a rough grading of tomatoes is practiced and 14 to 20 pounds of tomatoes are packed in the 12 or the 14 quart splint basket. These are marketed mainly in New Castle.

In the Kennett Square district the perfect fruits are usually separated into two sizes. There is seldom any difference in price between these sizes, the chief advantage being in uniformity of appearance. A third grade consists of the larger, but slightly imperfect stock while a fourth grade of the rough but solid stock may or may not be marketable.

In other sections the amount of grading depends in the growers and the market. Little may be done except the elimination of seriously deformed fruits.



Fig. 13. Grades of spring crop of tomatoes packed by one Kennett Square grower. 1. First grade; 2. Second grade same as first grade but smaller. 3. Field run. 4. Baskets ready for shipment.

Tomatoes from the Kennett Square Section are mostly sold on commission in the larger eastern centers, Philadelphia, New York, and Baltimore being the most popular. At times Boston is utilized, especially when New Jersey tomatoes begin to flood nearer markets. To the more distant points express and parcel post are used, but truck hauling is being used to an increasing extent. The concentration of the mushroom and floral industry in this same territory had helped to stimulate faster transportation, particularly to New York. Protection from freezing in winter is one of the serious problems in the use of the truck which is generally satisfactory in other respects.

VARIOUS PACKAGES ARE USED

The variations in the market price of Kennett Square tomatoes has resulted in an interesting practice in the use of packages in this section. During the fall and winter months prices are higher than during the rest of the year and retailers do not use as large a quantity of tomatoes as at other seasons. During this period a wire handled Climax basket holding 4 to 6 pounds of tomatoes and a splint basket, holding 10 lbs. are commonly used. Wrapping is also practiced at this season and assists in protecting against frost injury. During the spring and summer months larger units are desirable and the standard 12 quart Climax is often used. With the excelsior packing, the package usually contains fifteen pounds of tomatoes. Tomatoes produced in other sections find their way largely to local markets. Sixteen quart 2-handle splint market basket, sixteen quart hamper, and various second hand containers are used for the crop.

Some competition in tomatoes is provided by Californian, Mexican and Southern field-grown stock. The fruits from these sections must be picked quite green and therefore cannot compare in quality and appearance with forced tomatoes. However, with improved methods of distribution and transportation for the outdoor grown stock, this is likely in the future to influence considerably the price received for greenhouse tomatoes.

WESTERN PENNSYLVANIA GROWS MANY CUCUMBERS

Cucumbers are not as popular with Pennsylvania vegetable growers as either lettuce or tomatoes, but are grown in large quantities in the Erie section and in a smaller way in some other districts chiefly in the Western end of the state. The cucumber is grown extensively as a greenhouse crop in Ohio and as a frame and outdoor crop in the South, and these sources compete with those produced under glass in Pennsylvania.

Occasionally growers here try the cucumber as a fall and winter crop. At that season, prices are often three or four times those secured in the spring, but the greater amount of heat required in the winter, together with reduction of yield from insects, diseases, and unfavorable weather tend to discourage the growing of cucumbers at that season. The cucumber in Pennsylvania is primarily a spring crop, usually following two or three crops of lettuce that have been grown through fall and winter; or cucumbers may be started in early summer to follow a spring crop of vegetable plants.



Fig. 14. Intercropping cucumbers with lettuce.

Intercropping of cucumbers with lettuce is a common practice though not favored by some growers since neither crop grows well at temperatures most favorable to the other. However, the extra crop of lettuce brings in considerable return and probably retards the maturity of the first cucumbers but little. Early plants such as tomatoes, peppers, and eggplants, are also raised between the rows of newly set cucumber plants.

VARIETIES

A great many varieties are used for forcing most of them being of either the White Spine strains of the American type cucumber, or crosses of the American and English type. A few crosses of representative English varieties on White Spine strains have produced varieties with desirable characteristics of both classes, such as vigor and productiveness, medium length, dark green color and few seeds. The type cucumber most desirable for Pennsylvania markets seems to be medium in length, dark color, uniform in diameter from tip to tip, smooth surface, flesh tender, crisp, and good flavor. In general

greenhouse men are tending to favor a type with greater length of fruit than those generally raised in Pennsylvania, since the forced product is then quite distinct in appearance from Southern shipped stock.

Rawson's Hothouse, Arlington White Spine, and Vickery's Forcing are among the White Spine strains now grown in Pennsylvania. The Davis Perfect is perhaps the best known of the English-American crosses. The Deltus, a cross developed at Irondequoit, New York, is a comparatively recent introduction that shows promise. The Long Green, a cucumber of rather different type has grown in popularity as a greenhouse cucumber in the Middle West and is used by a few Pennsylvania growers. Seedsmen are depended upon somewhat for seeds of this vegetable, but a number of the growers have been selecting their own seed for years and have developed strains to suit their particular requirements.

LIGHT SOILS BEST

The cucumber may be grown on many types of soils but those containing a fairly high percentage of sand with a good organic content are most desirable. Greenhouse men located on heavier soils probably find other crops more profitable. Soils for cucumber growing should be sterilized in order to cut down the trouble from insects and diseases.

At the time of soil preparation in the fall, some farmers add all the manure for the season, together with some commercial fertilizer and lime. Others add about two-thirds of the total manure to be used at that time and the remainder just preceding the cucumber crop. Horse, cattle, pig, pounce, and sheep manure are all used for this crop by one grower or another. In Pennsylvania when manure is added just previous to the cucumber crop, it does not get sterilized and therefore may introduce insects or diseases to the houses. Most of the growers mulch the cucumber crop with half rotted manure about three or four weeks after the plants are set out. In some of the larger ranges this practice is considered too laborous and shallow cultivation is practiced until the cucumbers shade the soil, when all cultivation ceases. The mulch, with additional manure, is spaded in when the vines are removed, and the ground thus enriched for the fall vegetable crops.

Light applications of acid phosphate are sometimes made just before the mulch is applied. Bone meal, wood ashes, and rock phosphate are applied by various growers either when preparing the soil in the fall or following the three crops of lettuce. Nitrate of soda is occasionally used, if the soil seems to be lacking in nitrogen, or little manure has been used, to stimulate quick growth of the plants.

TRAINING AND PRUNING

There are three distinct systems of training and pruning of cucumbers used by Pennsylvania growers, the upright, the over-head trellis, and the A trellis systems. The upright system seems to be most popular. In this case the space between plants in the row varies from one to two feet and the distance between rows from two to five feet. One Pennsylvania grower allows two plants to a place with 18 inches between each pair of plants and three feet between rows.

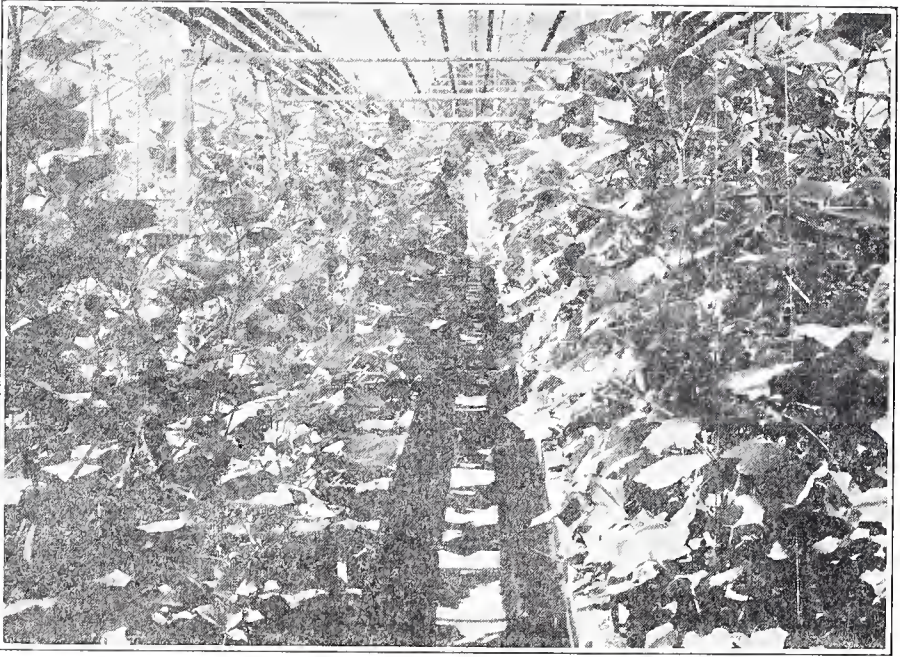


Fig. 15. Upright method of training cucumbers. These are planted in raised beds.

One grower in the state uses light stakes an inch in diameter with a small block on the lower end which rests on the ground alongside the plant and above is fastened to an over-head wire. The cucumber plants are tied at intervals along the stakes. Such a plan is commonly used in Ohio. In the overhead trellis system, the plants are usually set at greater distances than in the case of the upright system. The cucumbers as they develop hang below the over head trellis and are thus easy to harvest. The foliage on the trellis receives full benefit of the sun and at the same time shades the ground to a greater extent than does the strictly upright system, thus making the house a more pleasant place during the hot summer months. The A trellis system of training is popular in Pennsylvania only for houses that are too narrow for the other types to be practical or roofs too low to permit the use of upright training. The A trellis

does expose each plant to a maximum amount of sunlight and the fruit is easy to harvest. Plants are set 12 to 15 inches in the row with the distance between rows determined by the spread of the trellis.

TIME OF PLANTING

The time of planting cucumbers in the permanent beds will vary according to the other crops grown in the rotation. When preceded by lettuce, cucumbers are usually transplanted to the beds from March 1 to April 15, in Pennsylvania. Some growers produce their spring vegetable plants for field setting previous to the cucumber crop; such a plan delays cucumber planting until from April 15 to June 1 or later, thus making the resultant "cukes" a summer rather than a spring crop, and more competition is then encountered from outdoor growers.

TEMPERATURE AND VENTILATION

A temperature of 65 to 70 degrees at night and little more on cloudy days, and 15 degrees higher on sunny days, is generally followed. The temperature in summer will of course run higher than this, often going above 100 degrees, but if watering and ventilation are given close attention, no injury results. Ventilation of the cucumber crop should be carefully looked after. Cold drafts of air may check the growth of the plants and reduce the yields; but, fresh air is necessary at all times to maintain the vigor of the plants.

The cucumber, because of its succulent leaves and stems, and fruits which have a high water content, requires a large amount of both soil and atmospheric moisture for normal growth. Deficiency in this respect may cause the leaves to wilt with consequent reduction in yield, quality, and size of fruit. Overhead irrigation is largely used for this crop and helps to maintain high humidity. All watering should be done early in the morning on sunny days. Watering late in the day will knock many of the bees from the plants and drown them and may not permit the plants to dry off before night, thus encouraging disease.

POLLENATION

The sexual organs, pistils and stamens, are borne in separate flowers on the cucumber plant. When cucumbers are grown in the field, bees and other insects carry the pollen from the male to the female flowers and thus fertilize them. In the greenhouse, the pollen must either be transferred by hand, or bees must be kept, in order that pollination may take place. Unless the female flowers are fertilized they wither and drop (an exception to this is the pure English varieties, in which pollination is not always necessary for the development of fruit).

Hand pollination is too laborious to be practical so that most growers depend entirely on bees to carry pollen. The larger vegetable forcers have apiaries where bees are raised primarily for use in the cucumber houses. The smaller growers purchase hives as needed. With proper care the bees may be kept from year to year but many growers who do not understand bee culture as they do cucumber growing, allow their bees to die off and are forced to buy a new supply each year.

The number of hives required for a given area of glass depends largely on the strength of the hive, since a strong colony will do more work than a weak one. In any case it is important that enough bees be provided to pollenate thoroughly, otherwise a poor setting of fruit will result. For a house of 6,000 to 8,000 square feet one strong hive suffices though two would be preferable. If the cucumbers are planted very early in the spring, it will be necessary at first to keep the hives inside the greenhouse for early pollination. As the weather becomes more open, they are removed to the outside since whenever fumigations are given, the hives must be removed anyway to prevent injury to the bees. Common practice is to remove a pane of glass at the end of the house and place the hive outside the house and against this opening. The best hives are open at both ends so that the bees may enter the greenhouse to work, or may work on plants outdoors, this having the effect of stimulating greater activity and better health. The hives should be shaded wherever they may be placed to keep the colonies cool.

Cucumber flowers contain much pollen but practically no nectar. For this reason, early in the season, before nectar is available outdoors, the bees are provided with food in addition to the honey in the hives, such as sugar syrup or honey. Water should also be available though with the heavy syringing that the cucumbers receive, the bees may be able to get plenty of water without having a special supply provided.

Yields of cucumbers are quite variable, the number produced per plant depending on the system of training and pruning followed, the planting distance, the length of the picking season, the variety used, and the health of the plants. Two dozen to two and one half dozen cucumbers per plant is a good yield with the closer systems of planting, while the plants farther apart as in the over-head trellis system, a larger number per plant is often obtained. The price for the first spring cucumbers produced generally ranges about \$2.50 to \$3.00 a basket of 24 to 30, as the season advances the price drops to \$1.00 per basket or less.

INSECTS AND DISEASES

The greenhouse cucumber crop is attacked by a great variety of insects of which the following are reported as most important: Red

Spider, Striped Cucumber Beetle, Nematodes, Whitefly, Aphis, Thrips, and Sowbugs. Steam sterilization of soil will destroy nematodes and some other insects as well as diseases that may be carried in the soil. Red spider is kept in check by spraying with clear water under pressure, whitefly and thrips by cyanide fumigation, and aphids by thorough fumigation with tobacco. A poison bait made by dipping raw apple or potato in arsenate of lead and scattering it over the beds where sowbugs feed, is the best method of control for these pests.

The striped cucumber beetle in the adult stage usually does little damage from feeding upon the greenhouse cucumber vines but the larvae feed upon the roots and the beetle itself is also a carrier of the dreaded wilt. The beetles as a rule are more serious in the late spring, though they may enter the houses in the fall and remain there in the soil over winter. Cucurbitous crops should not be grown near the greenhouse, doors should be kept closed, and all beetles destroyed by some means as soon as possible after they enter the house. Some growers use a dust impregnated with nicotine which not only acts as a repellant but will also kill a good many of the beetles. Bordeaux mixture is also a repellant for the beetles but is not easily used when the plants become large. One Pennsylvania grower burns sulphur in the empty houses just preceding the planting of the cucumber crop, to get rid of all insects and some diseases at that time.

The most important diseases include Damping off, Fusarium wilt, Mosaic, Downy mildew, and Anthracnose. Damping off, on the young plants in the seed flats or seed beds, is prevented, as with other crops, by careful watering, proper temperature and humidity, and plenty of ventilation. Damping off the plants in the crop beds is generally due to Rhizoctonia, the disease that causes lettuce rosette. This trouble usually occurs following a lettuce crop that has been attacked by the same disease, and is prevented by sterilizing the soil between the lettuce and the cucumber crops with a strong formalin drench, four pounds of 40% formalin to 50 gallons of water. Such treatment should be necessary only if the disease has been present in the lettuce.

Wilt, a disease that causes rapid wilting of the plants as if from drought, can be controlled only through the elimination of the striped beetles which disseminate it, sanitary measures, and the removal of diseased plants. Mosaic is easily transmitted from plant to plant when pruning or picking, so it is best to remove and destroy infected plants as soon as they are discovered.

Downy mildew is favored by lack of light and sunshine, together with high humidity and high temperature. It is prevented largely through properly regulating such of these conditions as is pos-

sible. Spraying with Bordeaux mixture will also help in the control of this disease and of Anthracnose.

For control of insects and diseases of the greenhouse cucumber crop, the following schedule is followed by the most successful growers:

- Sterilization of greenhouse soil.
- Proper conditions of heat, moisture, and light.
- Spraying the plants both before and after transplanting to the beds with Bordeaux mixture.
- Fumigation of houses with tobacco or cyanide as occasion demands.
- Spraying plants with water under pressure.
- Use of poison bait (for sowbugs).
- Removal and destruction of diseased plants.
- Destruction and repelling of cucumber beetles.



Fig. 16. Erie cucumbers graded and packed for market. Left to right. 1. Basket ready for shipping. 2. First grade. 3. Second grade. 4. Third grade.

MARKETING

A rough sort of grading is practiced wherever greenhouse cucumbers are grown, well illustrated by figure No. 16. The same packages and marketing methods are used in the Erie and New Castle districts as for tomatoes, with 24 to 30 cucumbers packed to a basket. Various packages, mostly second hand, are used in other sections, and the produce marketed locally.

Some competition is provided on markets supplied through Pittsburgh by Ohio and Indiana greenhouse cucumbers and throughout Pennsylvania by Southern field grown cucumbers. This competition is not keen however since the demand greatly exceeds the supply of cucumbers grown under glass in this state.

BEETS

A firm at Northumberland grows beets to maturity in the spring, following fall and winter crops of radishes and lettuce. They are planted alone or as a companion crop with spring tomatoes. The same conditions prevail as for their lettuce crop, a soil fertilized heavily with horse and cattle manure, tankage and acid phosphate, with an annual sprinkling of lime. The last mentioned is very desirable for the beet crop. Temperatures as for lettuce are given the beet crop at the start but as they are maturing, the higher outside temperatures of late spring raise the house temperature. The overhead system of irrigation is used. The roots are pulled when of good size for bunching four or five to the bunch, and are placed on a nearby retail market. A quick maturing variety such as Crosby's Egyptian is used. Beets are grown for their tops in greenhouses in some states but not in Pennsylvania.

CELERY

Celery has never become an important forcing crop because of difficulty in growing it under glass and the competition at most seasons of the year with the field grown crop. One York County greenhouse owner is reported as raising celery as a winter crop, following fall lettuce. Heavy manuring (50 tons per acre), acid phosphate, nitrate of soda, and lime are used on the solid beds in the greenhouse in question. An easy blanching variety is used, and the plants set 7 inches by 7 inches. Spraying with Bordeaux mixture is practiced to control blight. The best demand for forced celery should come during the months of May and June after the Northern stored supply has become exhausted and the Southern shipments are falling off.

DANDELION

Dandelion, though an important frame crop in the Philadelphia section, is reported in the survey records as grown in only one small greenhouse in the state. The roots are grown outdoors during the summer and transplanted to the greenhouse in early winter. They are set out in the greenhouse walks between raised beds, alternate walks being used and the others left open for traffic. The dandelion greens are cut as they reach sufficient size, packed in a chip market basket and placed on a nearby retail market. The demand is limited so that the crop is not grown in large quantity.

FRENCH ENDIVE

French Endive is one of the minor forcing crops that is grown on a large scale in Pennsylvania only at Wysox, Bradford County.

where two firms are interested in its culture. There are small amounts grown in several other counties. French Endive is also known as Witloof Chicory, and as Belgian or English Endive. Thousands of baskets are imported to the United States annually from Belgium and France, this competing seriously with the product raised in Pennsylvania.

The crop is not well known on many of our smaller markets, and these seem to offer abundant opportunity for the Witloof grower, once the consumers in such localities learn to know and appreciate it as one of the finest salads that can be produced. Wysox growers ship the crop to New York, Philadelphia, Boston, Washington and other of the larger eastern cities where it now finds ready sale and increasing demand.

One firm at Wysox has been raising 20 acres of roots for forcing each year, and another ten acres. The roots for forcing are grown in the open in much the same way as parsnips. The soil needs to be light, deep, rich, and moist but well drained in order that long, smooth, tap roots may be developed. Roots with a diameter of $1\frac{1}{4}$ to $1\frac{1}{2}$ inches at the shoulder are considered most desirable. Small, crooked roots will never produce first class heads. Since there is great difference in the results obtained from different strains of seed, only the best seed obtainable should be purchased. Formerly, most of it was imported from France but at present some of the American seedsmen carry strains fully as good as the French seed. At Wysox the chicory is forced in frame buildings known as "heated root cellars," where hot water heat is used to maintain a temperature of 60 degrees.

Other places than special forcing houses may be used for the growing of witloof chicory, such as cellars where the proper temperatures may be maintained, the space under greenhouses benches, or in outdoor trenches. In all such cases the roots are handled in much the same manner.

Some roots will produce a number of small sprouts rather than one compact head. This may be due to injury to the crown previous to bedding. One man reported:—"Thinning out too much in the row causes production of small sprouts rather than single heads. Isolated plants that develop a loose crown with leaves tending to grow flat on the ground like a dandelion always produce a poor head and large number of small sprouts. I try to thin to three inches which provides the best size roots."

A rotting or rusting of the heads may occur in the forcing bed. One grower ascribed this trouble to a blight that had attacked the roots in the field. Watering too heavily or too often may cause this rotting or at least encourage its development. Rotted manure is often used in growing chicory roots, and there is no doubt that on many soils the use of this material will help to produce large roots.

Planting of witloof seed earlier than June 1 to 15 in this state is not recommended since many of the plants from early seedings will produce seed stalks in late summer and are therefore worthless for forcing, while sowings in early June produce roots with greater vitality.

The wholesale price on New York market ranged in 1920-21 from 8 cents to 35 cents, averaging 15 cents per pound, with demand steady, but considerable competition from the Belgium growers. In 1921-22 the price ranged from 25 cents to 45 cents per pound due to a short crop abroad and brought in reasonable returns but prices dropped again the next two seasons. A substantial tariff protection against the Belgian chicory is given as the hope of Pennsylvania growers for the future of the industry in this country.

MELONS

Pennsylvania contains the only sizable commercial melon forcing establishment in the United States, near North Wales, Montgomery County. Here six narrow houses 10 x 200 feet and two larger ones, 40 x 400 feet are devoted to the growing of tomatoes in the fall and winter followed by muskmelons in the spring.

The muskmelon is much more difficult to grow in the greenhouse than cucumbers or tomatoes and high prices must be obtained in order to realize a profit. The crop has therefore not been popular with greenhouse men in this country, though it is grown extensively under glass in England, under less favorable climatic conditions

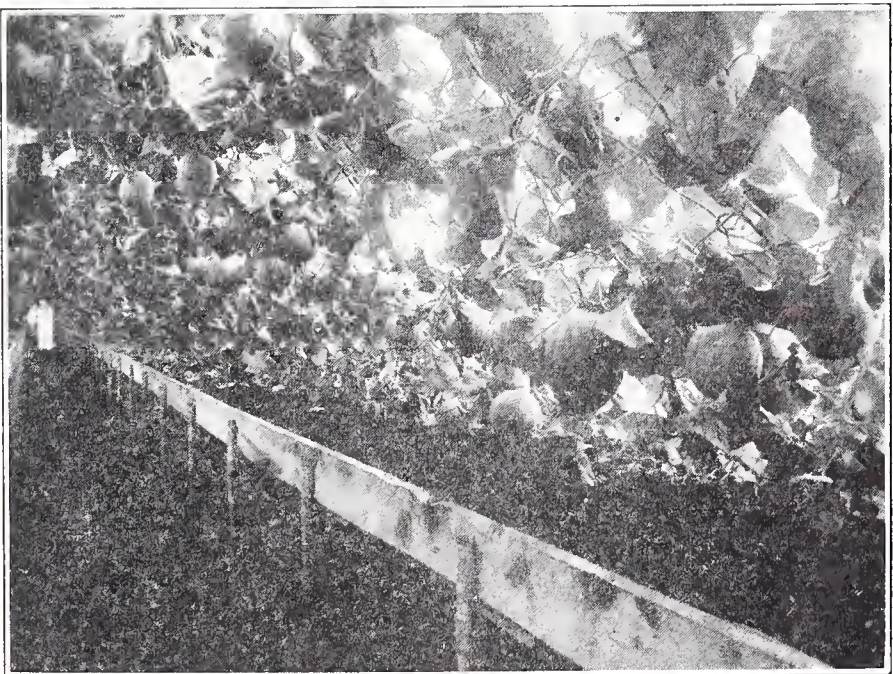


Fig. 17. Commercial melon crop grown in Montgomery County.

than we have in the United States. The quality and flavor of melons grown under the right conditions in greenhouses is far superior to field grown melons.

The culture of the melon is quite similar to the cucumber, though it is much more exacting in its requirements. Light, well ventilated greenhouses, provided with ample heat, should be satisfactory. Raised benches are preferred for the extra early spring crop because of the bottom heat that may be provided, but in this state the late spring crop is grown on raised beds.

VARIETIES AND SOILS

English varieties of forcing melons are usually used under glass. It is possible that some of the larger American melons might prove desirable for forcing in this country. The Montgomery County firm in this state uses a cross of an English variety and an American melon, seed of which cross has been selected for several years. These melons are 5 to 10 pounds in weight, orange flesh, fine quality, dark green skin when immature but well netted when ripe.

Fairly heavy loam soil is used in forcing this crop, well enriched with rotted animal manures previous to the growth of the tomato crop. The soil is sterilized annually. Lime is only occasionally used by this firm and then chiefly as a disease preventative. A complete fertilizer of high grade is used on the melons. When the fruits are set, a heavy mulch of manure is also applied.

GROWING PRACTICE

The proper watering of melons requires a large amount of care and experience. High humidity is essential for melons as well as for cucumbers, except when the melons are ripening and when pollination is taking place. The walks are sprinkled frequently and the plants syringed or sprayed with water. The melon requires temperatures of 70 to 75 degrees at night and on cloudy days; 80 to 90 degrees or above on bright sunny days. Young plants as well as those in bearing require high and uniform temperatures.

In the narrow houses at the North Wales range, the A trellis system of training is used and the melon plants are trained over the wires on binder twine. In beds in the large houses, the upright system of training is used, with binder twine fastened above to overhead wires, and below to the stems of the plants.

Pollination is usually done by hand rather than depending on bees, except late in the season when bees will come in through the open ventilators. When the melons develop to large size they are supported by a hammock improvised of twine and tied to the nearest overhead wire.

The same insect pests and diseases attack greenhouse melons as are found on the cucumbers. The most serious insects are probably red spider, white fly aphid, and cucumber beetle, with powdery mildew and wilt the diseases that cause greatest loss.

No intercropping is practiced in the large houses but on the benches in the narrow houses, the melon plants are set toward the rear of the benches, and flower and vegetable plants for spring sales are grown on the front half of the benches.

HARVESTING

Greenhouse melons are not picked until quite ripe. They then slip easily from the stem, and show other signs of ripeness as change in color and amount of netting. They are wrapped and packed in excelsior in 14 quart baskets, and are shipped immediately by express. Most of the Pennsylvania melons are shipped direct to hotels in New York and Philadelphia and a few are placed on the wholesale market in the latter city.

From one to two fruits to the vine is a good average for greenhouse melons. No attempt is made to secure more than two, all other fruits being pinched off if they form. The manager of the melon houses at North Wales reports a yield of 1200 pounds of melons from one of the 10 foot by 200 foot houses in 1921. The price received for greenhouse melons of fine quality runs from 50 cents to one dollar a pound. These exceptionally high prices are necessary if a reasonable net return is to be expected. Such prices, however, put the greenhouse melon in the luxury class, and the demand for them is therefor limited.

RADISHES

The radish is a minor crop of the Pennsylvania forcing industry, though there seems to be opportunity for producing a larger amount of this vegetable particularly near the smaller cities. The radish is a short season crop, brings quick returns, and may well take the place of lettuce in the rotation, or may be grown in the same houses with lettuce when the latter crop is most abundant on the market, thus avoiding the glutting of the market with lettuce.

CROPPING PRACTICE

The radish is comparatively an easy crop to grow, though more easily and quickly produced in bright sunny weather than in the dull cloudy days of winter. Radishes are grown both in ground beds and raised benches. On benches with heating pipes beneath they may be matured in winter more quickly than on ground beds, and for that reason benches are preferred at that season. Ground beds are commonly used where a spring radish crop is grown.

Radishes grown during the fall and winter may be followed in the spring by tomatoes, cucumbers, or vegetable plants. A grower in

Northumberland, Pennsylvania, follows lettuce and radishes by tomatoes and beets. Another Pennsylvania grower sows radishes between rows of sweet peas, while one man reports the sowing of radishes along the edges of the carnation benches. Some florists use radishes as a catch crop to occupy beds that would otherwise be vacant. An Altoona grower raises two crops of radishes in summer, following three crops of lettuce.

VARIETIES

As a rule, a small, turnip-shaped, bright red radish is preferred to varieties long in shape or white in color. The button types mature more quickly than the long radishes, require less space per radish and thus bring greater returns for the area occupied. Small topped types are desirable for forcing since they can then be grown more closely together without crowding. White Icicle, a long white radish of good quality, and some of the Scarlet Turnip White Tip strains are forced to some extent in Pennsylvania in addition to a number of the Scarlet Globe strains and French Breakfast. An Altoona grower uses the Pearl Forcing variety for his summer crop.

Great care should be exercised in the purchase of seed, that good forcing strains are secured. It would probably pay Pennsylvania vegetable forcers, if they are raising a large number of radishes annually, to select their own seed in order to improve the strains. In that way, greater uniformity of size, color, shape, and time of reaching marketable size, might be secured.

SOILS AND FERTILIZERS

As a rule in this state, the same soils that are used for lettuce production, are also used for radish growing. Most growers add rotted manure in the fall and supplement with dressings of commercial fertilizers before each crop or as top dressing during its growth. One grower spades in rotted stable manure before each crop in the rotation, which includes two crops of radishes. Commercial fertilizers used include acid phosphate, tankage, and bone meal. Where large quantities of animal manure are used, no further nitrogenous fertilizers should be needed for greenhouse radishes. Lime is usually applied as for the lettuce crop, an annual application previous to final preparation of the soil in the fall.

MARKETING

Forced radishes are carefully graded when bunching and only roots uniform in all characteristics and free from blemishes, are placed in the same bunch. Inferior types may be sold as a second grade product. From four to twelve radishes are used per bunch, this varying with market requirements as well as the preference of the

grower. The radishes are tied in bunches with raffia, tape, or string, then washed and packed for market. Chip baskets of 12 to 16 quarts capacity, holding from 6 to 10 dozen bunches are most popular packages, and crates of various sorts are used. Most of the forced radishes in Pennsylvania are marketed to retail stores or on retail markets, and in many of these cases no particular package is used.

Two dozen radishes per square foot of ground is considered a fair yield. One Western Pennsylvania grower reports a yield of 425 radishes per square yard. Prices are quite variable, running from 25 cents to one dollar a dozen bunches.

RHUBARB

Rhubarb has not been forced to any considerable extent in this state. Its indoor culture is not restricted to greenhouse owners, but market gardeners and truck farmers also produce it to some degree. Although rhubarb may be forced any time during the cold months, demand for it is found chiefly in the late winter and early spring. Rhubarb is forced under greenhouse benches, in special houses built for the purpose and in various kinds of cool, moist, storage cellars. One Pennsylvania grower forces roots in the greenhouse beds, a practice commonly followed in Massachusetts.



Fig. 18. Rhubarb forced in January in storage cellar.

Forced rhubarb is superior to outdoor grown rhubarb, especially if grown with little light. In such a case, the stalks contain more water than rhubarb grown in the open and are therefore less acid, the texture is particularly tender and crisp, the skin is thin, the

color is light pink, and the stems are longer than outdoor grown rhubarb. When grown in entire darkness the stalks are colorless and the leaf blades rudimentary. Color is desired by the consumer, and the development of some leaf blades adds to its attractiveness. Diffused light is therefore generally used.

The varieties and strains used for forcing are those that are commonly grown by gardeners in the field. The type of plant desired for forcing purposes is one that produces a fair number of large sized stalks rather than a great number of small ones, and these stalks should be pink in color.

GROWING THE ROOTS

The most common practice among Pennsylvania growers is to produce and harvest the rhubarb in the field for four or five years, until the crowns show signs of decreasing yield and size of stalks, and then use these crowns for forcing. Enough buds are saved from the plantation when digging to start a new outdoor patch. Such practice as the above may result in smaller stems of the forced product than if young roots, preferably two years old, are used. However, the expense of growing the two year old roots is considerable and good returns must be secured from the forced crop to make it a paying proposition. Growers in special rhubarb houses or in storage cellars, make beds five to six feet wide with paths between for convenience. Under greenhouse benches or in beds the roots are placed close together and covered lightly with soil or ashes.

In marketing, the stalks are tied in bunches of three or four large or a greater number of smaller ones, and a dozen stalks tied into a bundle. The use of red tape for tying is desirable since it adds greatly to the attractiveness of the product. The chip baskets are chiefly used for marketing forced rhubarb in Pennsylvania.

Yields and returns are quite variable but with good roots, should average better than four pounds to the square foot of bed. Wholesale prices of forced rhubarb range from 5 to 15 cents per pound.

GREEN ONIONS

Green onions are grown to a limited extent in a few Pennsylvania greenhouses. Either onion sets of any standard variety, or the sets of the Egyptian onion may be used. Benches or beds are used, and the same conditions are provided as for lettuce. The onions are cleaned, bunched, and marketed in the same way as the outdoor crop. Probably as large return is received from this crop as from lettuce but the demand at most seasons is much more limited.

PARSLEY

Parsley is grown only in a small way by Pennsylvania greenhouse men though there is a demand for limited amounts on most markets.

throughout the year. The same soil, moisture, and temperature conditions are maintained for this crop as for lettuce. Parsley, however, will thrive with less sunlight than lettuce, so it is frequently planted along the shady sides of houses where other crops would not grow so well.

A curly variety, as Moss Curled, is preferred for forcing. The plants may be grown in the field just as for the commercial outdoor crop, dug up in the fall, the leaves trimmed back to the crown, and the roots set 8" x 8" in the greenhouse beds. Many growers prefer to sow the seed in flats in August, transplanting the seedlings to pots when of suitable size, and to the beds in late September. One well known grower in the state believes a better crop is secured by sowing the seed directly in the greenhouse beds, thus not moving the plants at all. The beds are marked off with cross lines 8 inches apart, and a few seeds dropped at each intersection. Later all but one of the seedlings per place are removed.

Parsley may be an all season crop, remaining in the beds until late spring, or it may be followed by tomatoes, cucumbers, spring plants, and other crops. The parsley is made up into small bunches for market and these bunches packed in chip baskets or crates. Yields are quite variable but returns should be as great as for lettuce. An Erie grower, who plants a considerable number of parsley plants along the shaded edges of his lettuce houses, expects \$500 return from ten 200 foot rows.

NEW ZEALAND SPINACH

Until 1921 New Zealand spinach had been forced in Pennsylvania by only three greenhouse firms. In the New Castle section the crop proved for the growers a good substitute for lettuce, and the demand for this type of spinach is increasing as dealers and consumers learn of its merits. Some of this crop is shipped from New Castle as far as Altoona but the majority is marketed locally and enough has not yet been grown to supply the trade, though the area devoted to its culture has been gradually increased.

Any soil that will grow good lettuce seems to be satisfactory for New Zealand spinach. The New Castle firms treat the crop, as far as preparation of soil and fertilization are concerned, in the same manner as lettuce.

A night temperature of 60 degrees is desirable for New Zealand spinach. For this reason, when grown in the same house with lettuce, the Spinach crop makes its best growth in the warm fall and spring months, but if well established before cold weather, continues growth to some extent all winter. Judgment must be used in cutting since shoots longer than 4 to 6 inches may be fibrous at the lower end. Cutting stems so long that they are tough will quickly ruin the sale

of this vegetable. It is somewhat easier to judge the quality of the stems if they are broken rather than cut; but the latter practice is preferred by Pennsylvania growers since a smooth cut is not so subject to rot as an irregular wound resulting from breaking. The quality of New Zealand spinach is much finer when grown under glass than when grown in the open, in fact many consumers in the New Castle section will buy it in preference to outdoor spinach of the Victoria or Bloomsdale types if these types are competing on the market with greenhouse New Zealand. Dealers also like to handle this spinach since it keeps fresh a long time after picking.

There are no insects or diseases of importance that have proved troublesome on the New Zealand spinach crop, other than a rotting of the stem, caused apparently by overwatering.

New Zealand spinach cuts about the same weight to a given area as lettuce, is marketed in the same type of splint basket, and usually brings the same price per basket. There is less labor connected with its culture since one setting of plants lasts through the whole season. Where dealers are willing to introduce it, New Zealand spinach should prove a good substitute for lettuce as a forcing crop.

MISCELLANEOUS CROPS

There are a few other vegetables of minor importance as forced crops, that are grown to some extent in other states than Pennsylvania. These include asparagus, water cress, mint, sea kale, snap beans, cauliflower, kohlrabi and Swiss chard. Asparagus and sea kale require much the same forcing conditions as rhubarb. Cool temperature and a steady moisture supply are needed for water cress. Mint, cauliflower, kohlrabi, and Swiss chard grow well in situations suitable for lettuce, while snap beans do best as a spring crop since at that season plenty of sunlight and warmth are usually available. Some of the above crops are grown successfully in private greenhouses in this state and their culture under glass offers an opportunity for the man who has a market for them and wishes to diversify his crops, and thus avoid overproduction of the more common forcing crops such as lettuce.